ENGINEERING

An Illustrated Weekly Journal

EDITED BY CHARLES COOPER AND J. FOSTER PETREE.

35 & 36, BEDFORD STREET, STRAND, LONDON, W.C.2. TELEPHONE: TEMPLE BAR 3668.

VOL. 176—No. 4576 LONDON: FRIDAY, OCTOBER 9, 1953. PRICE 2s.

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A LARGE UNIVERSAL BORING MILL.

A REMARKABLE machine tool which has been installed at the Rugby works of the British Thomson-Houston Company, Limited, will enable that firm to machine exceptionally large and awkward components of electrical machinery. Basically, it is a boring mill, but it is so adaptable in its design that it can also be used for turning, facing, milling, slotting, planing, etc.

GENERAL CONSTRUCTION AND SCOPE.

The main rotatable table, 25 ft. in diameter, is mounted with its top surface at floor level, and around it are several fixed T-slotted floorplates. The 25-ft. diameter table is visible in Fig. 1, below, which shows part of a fabricated stator-frame assembly being machined. On the right-hand side is the main column, to which is bolted the main horizontal cross-slide. A saddle which is fitted to ways on this cross-slide carries a sub-slide which can be inclined to the horizontal at any angle up to $\pm$ 15 deg. The sub-slide itself can be used to mount either a standard tool-ram unit with banjo mounting, as shown in Fig. 1, or a powered vertical milling head. The outer end of the main cross-slide is given support from a back column by means of an arm which is cantilevered out from the back column. This back cantilever arm, as it is termed, consists of four fabricated sections bolted together, as will be seen more clearly in Fig. 3 on the next page. One of the sections can be removed if the job being machined is small enough to allow the back column to be moved in closer to the main table, thereby providing a more rigid support to the outer end of the cross-slide.

The main column is provided on its front face with vertical slide-ways which carry a rectangular table of the type used on conventional horizontal boring machines. This table is arranged vertically —on edge, in effect; it can be seen near the bottom of the main column in Figs. 1 and 3, and near the top of the column in Fig. 5, which is a drawing showing the general arrangement of the machine. The rectangular table, or "front" table as it is called, mounts a horizontal boring head. A similar table can also be fitted on slide-ways at the back of the main column, but in this case the table is raised and lowered by coarse-pitch screws so that, in conjunction with a knee-type tool-bar holder, it can be used for heavy vertical-face slotting or planing.

A boring bar, 22 ft. 3 in. high, which is shown in Fig. 2, can be set up in the centre of the main table with an independent drive, as shown in Fig. 5. A split-mounted balanced boring head can then be fixed to the boring bar, and work with internal diameter from 27 in. to about 14 ft. can be bored. The work, mounted on the main table, can be held stationary while the boring bar rotates, or both can be rotated at different speeds, giving a wide range of differential speeds, particularly suitable for machining relatively small diameters.

Electrical connections can be made through slip-rings on the main table (Fig. 5) so that, if required, portable machine-tool units or even welding sets can be mounted on the main table. Work of considerable size and open in the centre can be mounted on the fixed floorplates surrounding the main table; and the main column, with or without the cross-slide, can then be mounted on and rotated by the machine table. Portable machine tools, such as horizontal boring, slotting and milling machines can be mounted on the floorplates as well as on the table.

The boring mill will take work up to 42 ft. 6 in. in diameter and 14 ft. 6 in. high. A maximum weight of 120 tons can be rotated and a series of heavy extension arms can be fitted to the table when required for special work. The estimated weight of the foundations and surrounding floor rails and bedplates is 620 tons, and the machine parts below floor level weigh about 200 tons. The whole superstructure weighs about 155 tons. In designing and constructing the boring mill, the British Thomson-Houston Company had the co-operation of many firms in the machine-tool industry, some of whom are mentioned in this article. In addition, assistance in machining the fabricated parts of the superstructure was provided by the English Steel Corporation, Limited, Craven Brothers (Manchester), Limited, and Markham and Company, Limited, and by the Davy and United Engineering Company, Limited, for the special long-feed screws and shafts. The foundation work was carried out by J. Parnell and Son, Limited, and the steel reinforcement was designed and supplied by the British Reinforced Concrete Engineering Company, Limited. The handrails and access platforms were made by Steelway, Limited, to B.T.H. specification.

MAIN TABLE.

A George Richards 25-ft. diameter table forms the centre of the machine, with a standard under-

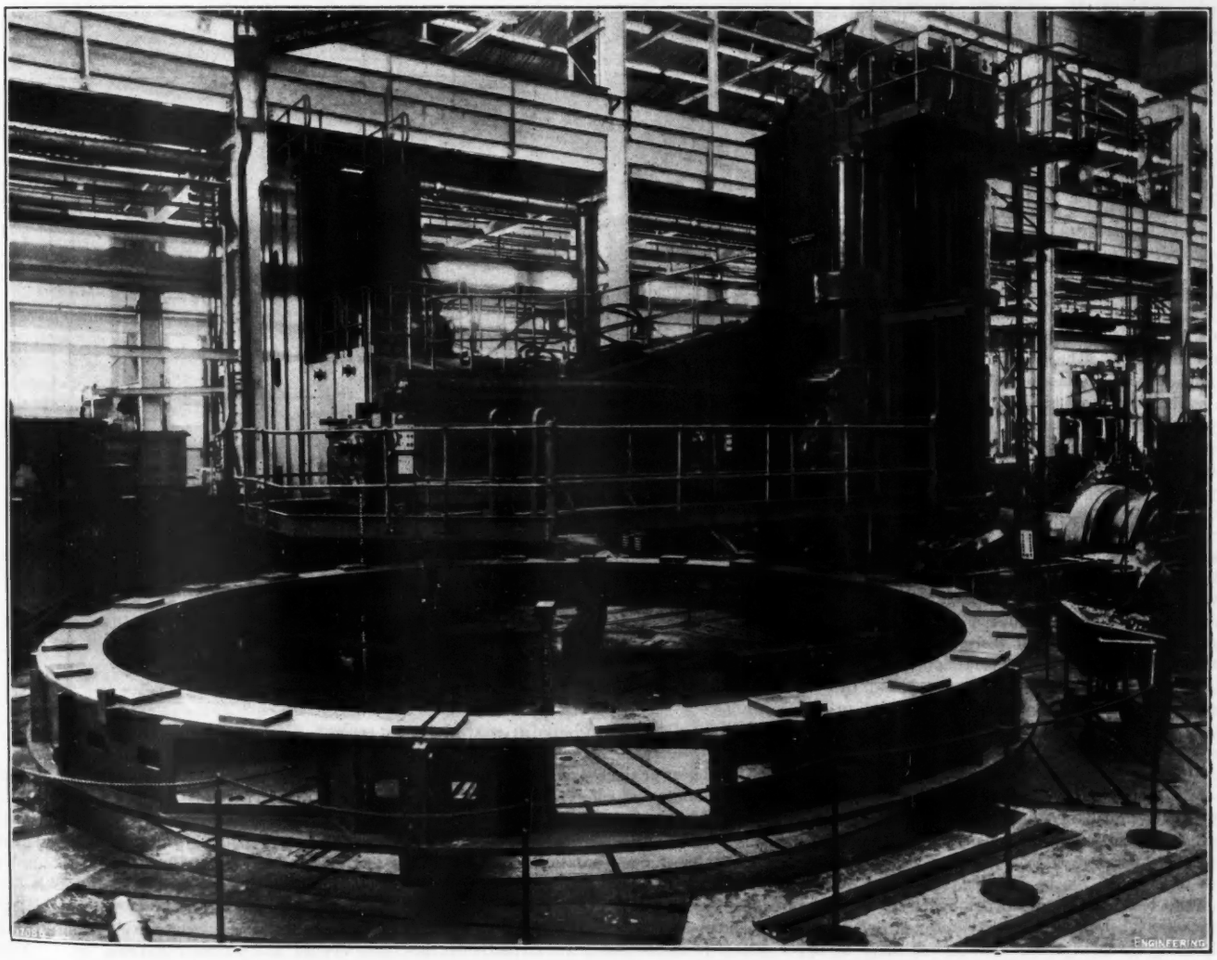

FIG. 1. MACHINING PART OF A FABRICATED STATOR FRAME ON 25-FT. TABLE OF BORING MILL.

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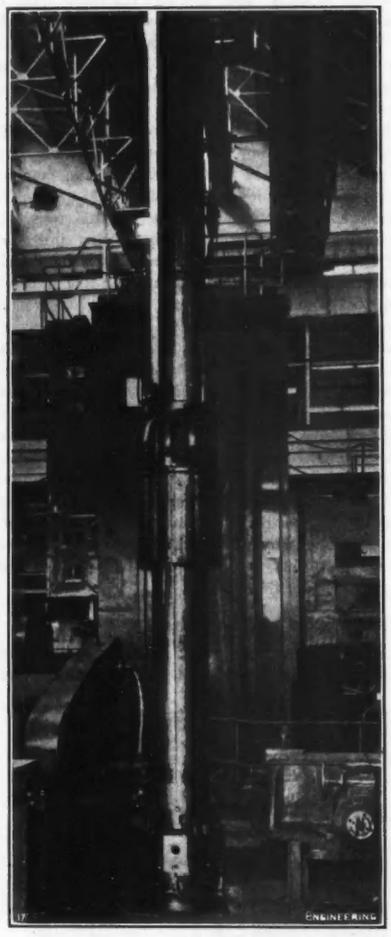

Fig. 2. Vertical Boring Bar.

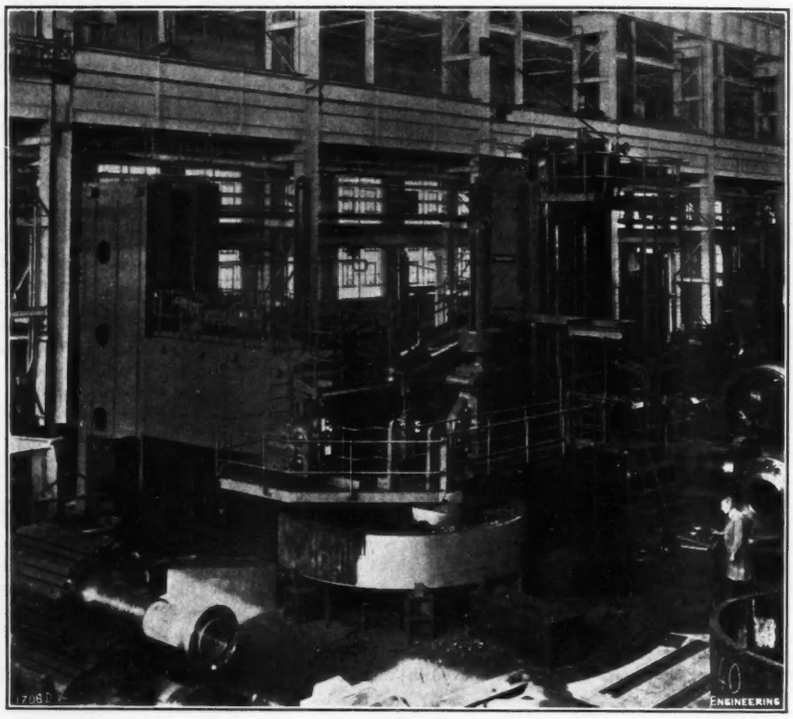

Fig. 3. Boring Mill, Showing Arrangement of Columns and Cross-Slides.

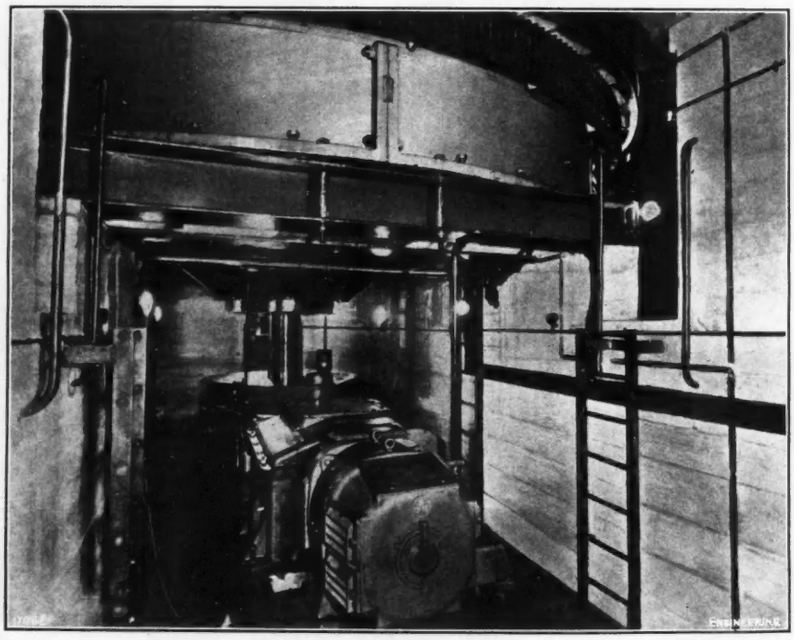

Fig. 4. Boring-Bar Motor and Drive below Main Table.

structure modified to give in-line drive by a B.T.H. 110-h.p. 500-volt direct-current reversible motor with a 3-to-1 speed range, through a gearbox with six speed changes. The gearbox has an electrically-operated gear-change mechanism. Both the motor and gearbox are in a side annexe, opening off the centre well of the foundations. The table can also be rotated by hand to any angular setting observed through a sight-glass set in the floorplate adjacent to the operating position. It may also be "inched" round under power. Around the periphery of the table, and near the lower skirt edge, a Chesterman steel-strip tape is fitted in a groove. This tape is marked off in 360 principal divisions. Sub-divisions of degrees are marked and the tape can be brought around to a zero position independently of table movement and then locked to the table, which then functions as a large dividing plate immune from backlash errors. Optical equipment supplied by Optical Measuring Tools, Limited, sights on to the tape and reflects on to a graduated vernier scale below a sight-glass in the floorplate. The scale is adjustable to compensate for slight errors in the tape-scale setting. This feature is useful when setting out radial-angle operations, frequently encountered in electrical work. To prevent rotation of the table when it is set for index work, two Ferodo-lined brake blocks 180 deg. apart can be brought to bear on the table skirt by means of a wedge action behind the shoes, initiated by a Lockheed hydraulic system. The power drive is electrically interlocked to prevent operation when either the hand gear or the brake shoes are engaged, or the various lubricating-oil systems are not functioning correctly.

A top bearing is formed, in the centre "stalk" of the main table, for a separate boring-bar drive shaft which terminates in a flange-end slightly below the table surface (Fig. 5). This flange has a series of tapped holes and a large driving slot across its upper surface to secure and drive, respectively, the boring bar. The shaft extends downwards into the foundation well and terminates in an independently-driven George Richards gearbox, which has six mechanical gear changes, and an in-line drive from a B.T.H. 30-h.p. 500-volt direct-current 2-to-1 speed-ratio motor (Fig. 4). This boring-bar drive unit is designed to carry a vertical load of 60 tons. Rotation speeds of the main-table and boring-bar drives are respectively indicated, in both forward and reverse directions, on two 30-in. diameter etched-glass indicator dials, which are

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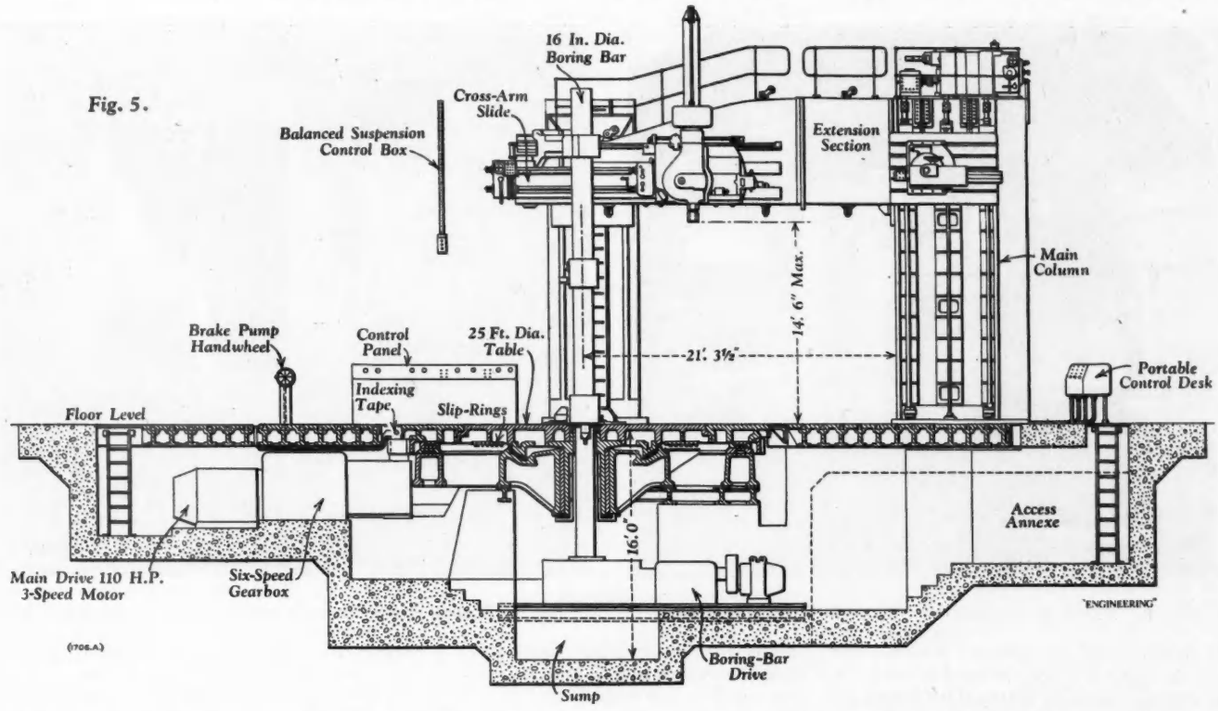
Fig. 5.



back-lighted. These indicators, made by the Record Electrical Company, Limited, are suspended side by side under a projecting gantry of the shop gallery, and at 25 ft. 6 in. above the floor level they give a clear indication to the operator.

In the surface of the machine table are openings, normally covered, giving access to electrical sockets mounted under the table and connected to the 440-volt three-phase 50-cycle slip-rings on the underside of the table. There is one plug point (100-ampere capacity) for heavy power requirements on the table, and in connection with this there is a multi-point "splitter" pillar unit. This unit can be plugged to the 100-ampere table point and bolted to the table in a convenient position, when switched supplies can be taken from the various plugs on the pillar at 15, 30, 60 and 100 amperes. Other plug points in the table give a 50-volt supply by means of 440/50-volt B.T.H. "Lo-volt" lighting sets; portable handlamps can thus be supplied. There are also three plug points for the "emergency-stop" circuit. When not in use, short-circuiting plugs are left in these sockets. The "emergency-stop" control is on a trailing lead when in use, thereby enabling an operator on the table to stop the whole machine in an emergency.

Boring Bar.

The boring bar, when not in use, is mounted on a special plate in the floor adjacent to the machine. The bottom end of the bar is enlarged to form a gearbox giving high, low, and neutral positions. The body of the bar has two slots, one accommodating a vertical-traverse screw for a boring head, the other taking a key-wayed shaft for a cross-traverse drive. A Meehanite sleeve is keyed to the bar, using the two slots for driving, and this sleeve is machined on its outer surface to receive boring tools and short boring-tool holders. On the traverse-shaft side, a take-off with bevel gears is arranged for outward (or radial) traverse drive. The sleeve is accurately machined on its outside diameter to take the split-mounted balanced boring heads for boring larger diameters. Boring-bar speeds of up to 28 r.p.m. are available, and these, in conjunction with differential running of the table, enable rotating work to be machined on its larger diameters or bored on smaller diameters at a useful machining speed. The gearbox is star-wheel driven from a series of retractable strikers held in a mounting plate affixed to the centre of the main table. Differential speeds of the bar and table are thereby provided and the drive can be reversed by changing over the star-wheel to the opposite side of the gearbox. Independent hand or power drive can be arranged through a shaft in a recess at the side of the gearbox. The traverse speed may be varied in either of the two ranges provided by the gearbox, and also by using different numbers of striker arms, of which a total of 12 are provided.

Above the sleeve on the bar is a spherically-seated split-bearing bush rotating on a steel sleeve which is keyed to the bar but is free to move in an axial direction on it. On the upper surface of this bearing there is an automatic Wakefield lubricator for supplying the bearing with oil. The lubricator is operated by a cam on the upper end of the liner sleeve. A housing with a spherical seating to receive the bearing shell is provided for attaching to the face of the main cross-slide, along which it is screw-operated for a limited distance. The housing incorporates a slide-face at an inclined plane to the main mounting plane, the combination of the two movements enabling the housing to be accurately centred around the bearing on the bar. For ease in assembly and dismantling the housing cap is hinged. Thus the boring bar may be equipped with an outboard bearing on the superstructure of the machine, adding greatly to its stiffness and true running.

Main Column.

The main column is bolted to a heavy floorplate at the right side of the machine and may be placed up to the table periphery or at a greater radial distance to suit working conditions. The column (excluding the top gearbox, etc.) is 22 ft. 3 in. high and the base dimensions are 9 ft. 6 in. by 6 ft. 9 in. It was fabricated in the Rugby works from steel plates and stress-relieved before machining. Heavy slide-ways up the front and rear faces of the column are of chilled cast-iron sections fitted and bolted to steel ways. On the side of the column nearest the table are two machined and tapped steel facings. These facings are also drilled and reamed for dowels, and both the dowel and tapped holes are at regular pitches in co-ordinate dimensions. A George Richards horizontal boring-machine table has been adapted and fitted to the vertical ways up the front of the column. This table is equipped with the same firm's side-head tool ram, inclinable in a vertical plane with a movement of 30 deg. downwards, and controlled by a handwheel through a worm gear for self-holding adjustment. The hand movement of the ram is intended for radial positioning, but both the vertical and cross power-traverse movements are applied through the table mechanism. The power cross-traverse is through a vertical shaft between the main ways; vertical traverse is by two lead-screws outside the ways. These shafts are carried in Timken tapered-roller bearings and are coupled to mating extension shafts projecting downwards from a gearbox on the top of the column.

The side table is counter-balanced by guided weights inside the column, interconnected by Renold balance chains. Mounted from the side table is a "floating" operating platform; and guides on this platform restrain an access ladder which serves both the table platform and the platform at the top of the column. When the table and platform move sideways they move the ladder, which is supported under the top platform on track runners. The ladder sides are extended upwards to connect to the handrailing of the upper platform, and the connected sections of the handrailing on each side are telescopic, to follow the side-to-side movement.

As the main column is adjustable in position on the floor, the conventional method of mechanical interconnection with the main table was impracticable. Moreover, it was envisaged that the column may itself constitute a portable machine-tool unit. A B.T.H. "Emotrol" (electronic motor control) system, receiving its reference voltage from a tacho-generator directly driven from the main table gear and operating through a control panel, was there-

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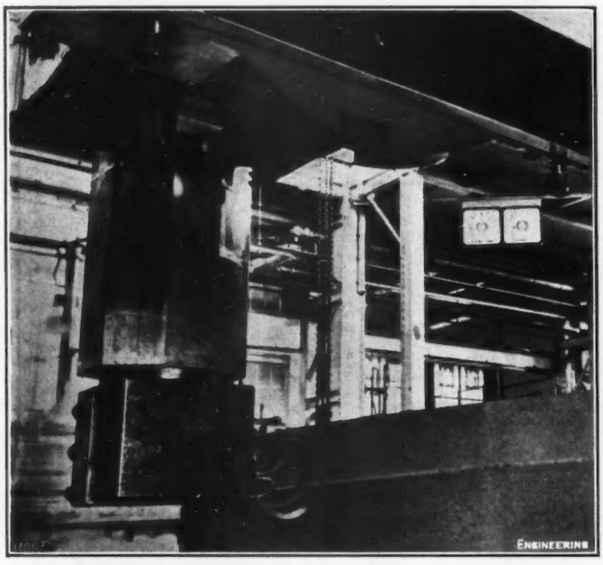


Fig. 6. Machining in Progress, Showing Speed Indicators.

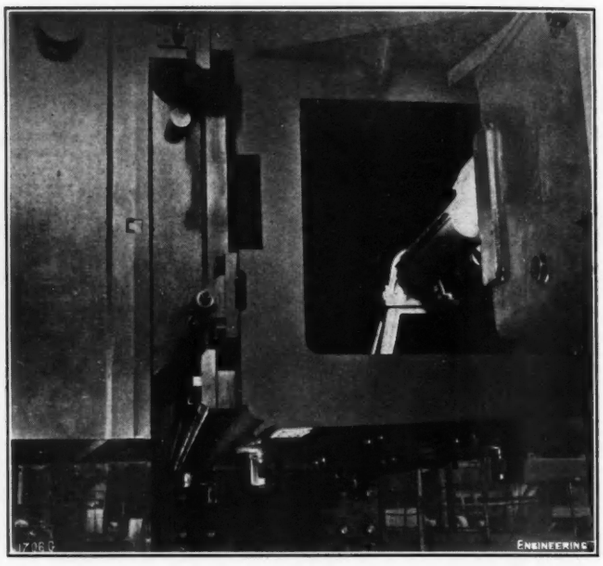


Fig. 7. Wedge-Shape Closing Section of Back Cantilever Arm.

fore developed and incorporated. It ensures that, when the circuit is closed, the speed of the driving and traverse gearbox on the top of the column is in absolute synchronism with the table speed. The motor drive is connected to a George Richards feed gearbox which is fitted with an independent motor for fast traverse. Also contained in this top unit is a motor-driven oil pump for lubricating purposes. On the side of the column remote from the machine table is housed the main switchgear, the control panel, sub-circuit switches, etc., for supply and distribution to the column, and also the circuits to the main cross-slide. Leading to the column is a trailing cable having a heavy supply plug, which fits into an adjacent socket in a sunken box in the floor. In view of the possible use of the column as a portable tool the following arrangements were incorporated. When the heavy-current plug is connected to a normal 440-volt three-phase 50-cycle supply, the Emotrol motor runs at a constant speed governed by the supply frequency. This speed is so arranged that the mechanical speed ranges, as depicted on the feed dials, are accurately obtained.

The front table is suitable for mounting a horizontal boring-head unit complete, and supplying it with electric power, thereby giving an exceptional range by reason of the vertical and cross movements of this table. At the back of the column, the slides can be used for a table similar to that at the front. This table would be used for heavy vertical-face slotting or planing work, as already described. Recessed into the column, between the faces which receive the cross-slide, are multi-point sockets at various heights.

Back Column.

The back column is fabricated from steel plates and sections. It is 22 ft. 3 in. high and its base dimensions are 8 ft. by 6 ft. 11 in. In this case also it is possible to adjust its position on the floor-plates to a considerable extent, on axes parallel and at right-angles to the face of the main cross-slide. Side bollards are welded on at the top of the column to enable it to be lifted readily. Drilled and dowel holes are provided in the two machined faces on the front of the column, arranged in exactly the same way as those in the main column and corresponding dimensionally. Between these faces is a box recess extending the whole height; steel rungs in the recess allow access behind, as well as through the back cantilever arm when it is bolted to the faces. Inside the back column are several diaphragm plates with passage holes, and an internal ladder. These facilities permit the bolts which are passed through the faces to be tightened up easily. On the right and left sides of the column are facing strips and brackets enabling various items of equipment to be stored off the floor, and readily positioned or removed by crane. They can accommodate the boring-bar striker-plate assembly, and either the main tool ram and banjo mounting or the vertical milling head, depending on which is in service. On both the main and back columns the inner edges of the steel faces are accurately machined to form a vertical channel with inclined sides to receive and locate the cross-slide and the cantilever arm, respectively.

Main Cross-Slide.

The main cross-slide is a cast-iron member of box cross-section, heavily ribbed, and flanged at one end to mate to the main column. It was cast by Vickers-Armstrongs Limited. The underside is flat and horizontal; the upper surface is parabolic. At the front are integral ways and an upper T-slot slide to receive a George Richards sliding-head unit, and at the outboard end facings are used to mount a George Richards feed gearbox unit. Also at the front are subsidiary slide faces to accommodate the bearing housing which gives additional support to the centre boring bar. The back face of the arm has a machined centre channel, and facings parallel to the front ways. Access to the inside of the arm can be obtained at the outboard end, which is left open for this purpose.

Inside the arm is a B.T.H. geared motor unit and connecting shaft to the feed gearbox, a control panel for the Emotrol equipment and a Wayne cable reel from which power supplies may be fed through the front surface of the arm to the tool slide. A central aperture in the main flange enables connections to be plugged through to the face of the main column, using the socket points already mentioned. Speed control is precisely as for, but independent of, the method adopted for the front-table movement of the main column; similarly, connection to a normal alternating-current supply can be made when it is desired to use traverse movements independently of the main table movement. This position is of value when a milling head is substituted for the normal tool ram. The main saddle carries a sub-slide which, as already noted, may be inclined to the horizontal at any angle up to $\pm$ 15 deg. This sub-slide has powered movements, and for short surface work, within its compass, it can be levelled and used without the main arm being levelled. The facing on the sub-slide is designed to take not only the standard tool-ram banjo mounting but also a Kendall and Gent 20-h.p. vertical milling head, with a hand-operated vertical feed of 10 in. and integral control equipment. The inclination to the vertical obtainable on the tool ram can also be obtained on the milling head. This milling-head assembly is supplied with power through the cable from the cable reel housed in the arm; the control arrangements ensure that the head is used either when the main table is under power or when the table is locked and not under power. Limit switches are provided for the various slide movements in accordance with usual practice. Control is readily exercised from the vicinity of the mechanical controls on the feed gearbox.

Four lifting bolts pass right through the arm casting, and enable the entire unit to be handled by crane. The flanged end has a vertical register, with bevelled vertical faces, to mate with the corresponding vertical recess in the face of the main column, and it is drilled to receive bolts which pass through and screw into the main column facings. When mounting the arm on the main column, a heavy bearing plate is first bolted to the main column facings to act as a support to the lower edge of the flanged end. This bearing plate has two substantial dowels with tapered lead ends. The dowels engage with the jig-drilled dowel holes in the main column facings, and, after being assembled at the selected height position, the plate is solidly bolted up to the column. The upper edge of the bearing plate is so disposed dimensionally to the dowel holes (the dowels are capable of taking the shear load of the entire main-slide arm), that when the machined bottom edge of the arm flange is rested thereon, the holes in the flange are correctly disposed in relation to the tapped holes in the main column surface. There are four vertical rows of

bolts to this bolted connection, the two inner rows lying within the inner chamber or core of the arm, and the two outer being accessible respectively from the back and front faces of the arm. Access to the inside of the arm for bolting up is obviously readily secured, but on the outer faces erection is assisted by a welded saddle frame of tubular members. This frame is a separate unit which can be dropped over the cross-slide arm adjacent to the flanged end, without interfering with the lifting arrangements. Each leg of the frame is an enclosed ladder-like member with a box bottom to contain the required bolts. The operator is thus able to insert the bolts and tighten up with a power wrench. In those cases where the work is exceptionally large, rotatable, and necessitates centre as well as outside machining, the main slide arm is lengthened by a fabricated extension section 6 ft. 3 in. in length. Outer-diameter machining, in the case of this set-up, is performed from the side ram and front table of the main column.

The main slide arm is liable to deflect due to its own weight and to tool cutting loads. Provision is therefore made for levelling it before it is finally secured to the back cantilever arm. A screw-operated jacking device is incorporated in the fourth section of the cantilever arm, i.e., that nearest to the main slide, so that the outer end of the main slide can be jacked up relative to the cantilever arm. The section of the cantilever arm containing this device is wedge-shaped in plan (Fig. 7) to allow it to be moved along horizontally (on two roller bearings which take the weight) and thus conform precisely to the distance between the back of the slide arm and the third section of the cantilever arm. This is the principle used to "level up" the main slide-ways. It is interesting to record that the surface of the main table, when faced on site, was truly plane across the 25-ft. diameter to within 0·002 in.

During erection the back cantilever arm was test-loaded at its extreme end with a load of 45 tons, and the deflections carefully checked. As the loading due to the jacking action is estimated at 20 to 25 tons, careful measurement of the distances between the faces of the third section of the back cantilever arm and the back faces of the main slide, as set up on trial assembly, enabled these dimensions to be corrected to allow for the various strain deflections. The wedge portion, which had purposely been left oversize on length, was then faced to suit.

Electric Control System.

The main electric control system is of B.T.H. manufacture and is in three principal sections: the main control board, a desk-type control unit, and a pendant control suspended from a jib. On the main board is the main isolator, switches for the lighting of the speed-indicator panels and optical-sighting gear for angular setting of the main table, and power to the slip-rings and sockets on the main table. Adjacent are lights indicating "table alive" and "indexing clutch engaged," together with the locked switch for "boring and turning" or "milling and slotting," which interlocks when the milling head is in use. These are followed by the cubicle for table control, i.e., start and stop, forward, reverse, inching control, raise and lower speed control, and "emergency stop" push-button. The oil-pump "start" and "stop" controls and an indicator light are grouped for the main table and for the boring-bar drive. The last operating cubicle is for the boring-bar drive and is similar to that for the main-table control.

The desk control is trolley mounted and is connected by a multi-core trailing cable and multi-pin plug to either of two socket points sunk into the floor surround. This connection enables the desk to be moved to any convenient operating point outside the table and work periphery, from the main column to the opposite side of the table. On the desk panel are controls for the table and boring bar (duplicating those in the main control panel) and, in addition, gear-change push-buttons for the main-drive gearbox giving six gear changes. Indicating dials show the gear positions, and there is an emergency "stop" button. The pendant control carries the principal controls for the main table and the boring bar, and also an emergency "stop" button.

In order to assist the factory planning section in arranging the disposition of the various units, charts are made to give a ready indication of the various ranges of movements, thus facilitating changeover.

LITERATURE.

Stahldraht: Seine Herstellung und Eigenschaften.

By Professor Anton Pomp. Second edition, Verlag-Stahleisen m.b.H., Breitstrasse 27, Düsseldorf, Germany. [Price 38 D.M.]

In the preface to the first edition of his book on steel wire, Professor Pomp notes that, until recently, the wire-drawing craft was shrouded in secrecy; even now, many wire mills refuse to admit visitors for fear of disclosure of supposedly secret and superior processes. This attitude is not only regrettable, but almost ridiculously shortsighted, for, as he observes, there is a great store of published scientific knowledge about wire manufacture of the utmost practical value. His aim has been to place this knowledge at the disposal of those engaged in the steel-wire industry. To write a book of this kind, there is to-day no one better qualified than Professor Pomp.

The first appearance of his book, which occurred during the war, did not receive the notice it deserved. In the second edition, the text has been brought thoroughly up to date, especially on developments outside Germany. The book inevitably invites comparison with its well-known namesake by Bonzel. Though approximately the same in size, the books greatly differ in contents and treatment. Much of the difference is no doubt due to the time that intervened between their first appearances, which is why Bonzel's book is now out of date on industrial practice, while Pomp has managed to include data on industrial developments right up to the end of 1951. Whereas Bonzel had to rely largely on applying to problems in wire manufacture scientific knowledge gained outside the field of wire-drawing, Pomp has drawn on a mine of experimental findings concerning wire. The expert will, indeed, be grateful to him for his skilful collation of the findings of so many investigators, and for the orderly exposition which facilitates reference to particular aspects of problems. He deals comprehensively with the condition, properties and faults of rod; pointing, descaling, liming; the fundamentals of wire-drawing and properties of drawn wire; machines, dies, and ancillary equipment; lubricants; annealing, patenting, and other heat treatment; galvanising, tinning, polishing and other finishing processes; and testing. Historical notes and data on wire gauges are included. The text is amply illustrated and documented, with over 800 references, and thoroughly up-to-date.

Opening of Lackenby Steelworks.—Messrs. Dorman, Long & Co., Ltd., have begun steel production at their new Lackenby open-hearth steelworks in North Yorkshire. An official announcement states that a tilting furnace of 360 tons capacity and an active mixer of 600 tons capacity have been brought into use. A second furnace is to be commissioned soon and two more furnaces and another mixer at a later date. The completion of these works marks the end of the first and second stages of the company's 50,000,000*l.* development scheme. The third stage, costing 36,000,000*l.*, has been commenced.

ANGLO-AMERICAN AERONAUTICAL CONFERENCE.

(*Concluded from page* 425.)

Boundary Layer and Circulation Control.

Two aspects of boundary-layer control research undertaken in the United States were described in a paper on "Some Recent Advances in Boundary Layer and Circulation Control," by Mr. Courtland D. Perkins and Mr. David C. Hazen. At the Mississippi State College, flight experiments on a sailplane had been carried out on the control of boundary-layer transition by distributed porous suction on the upper aerofoil surface. From these tests it was found possible to reduce the total drag of a profile considerably (in a particular example, by 54 per cent.) with very low suction quantities. The porosity should be distributed so that the suction just maintained a laminar boundary layer without over-reducing the boundary-layer thickness. Too thin a boundary layer had been found to result in transition. It was suggested that, at higher speeds, better results might be obtained by first reducing the amount of suction and then, to avoid transition, by artificially increasing boundary-layer depth near the nose, possibly by a blowing slot.

The other investigation, by the Princeton University, which was concerned with increasing lift through circulation control by suction through trailing-edge slots, had led to one of the most interesting recent developments in subsonic aerodynamics—the discovery of a means for creating and stabilising a vortex trapped within a cusp. The flow resulting from the vortex had a considerable effect on the downwash pattern, and, it was believed, would provide a means by which very high lift coefficients might be obtained. The lecturers concluded that the time had arrived when the design of an aircraft should be based on a flow control system, rather than modifying an existing aircraft to utilise some form of control.

Pod Mounting of Jet Engines.

The American philosophy on long-range aircraft, as typified by the Boeing B.47 and B.52 bomber aircraft, in which the jet engines were mounted in "pods" suspended below the wings, was outlined by Mr. George S. Schairer, in a paper on "Pod Mounting of Jet Engines." The primary considerations governing the choice of pod-mounted engines by the Boeing company had been those of safety and accessibility for maintenance. A multi-engined aircraft, he said, should be designed so that failure of one engine should not influence the failure of another, and should not endanger the airframe. Pod-mounted engines were ideal in this respect. Although jet-engine failures did not usually cause external damage or fires, such failures could occasionally occur, as in the event of a bearing failure, which could apply a powerful wrenching moment on the mounting. The flexibility of the pod mounting reduced the chances of mounting failure in such circumstances. In the event of turbine or compressor blades stripping and being thrown through the engine, or a turbine disc failure, or even an engine coming adrift, the pod-mounted engine offered less risk to the aeroplane structure.

Aircraft fires, probably the most serious safety aspect, usually originated in the power plant. The most important consideration in avoiding power-plant fires was to shut down the supply of combustible fluids to the fire. In the pod-mounted engine, the fluid shut-off valves could be located in the wing so that any failure or fire in the pod structure would not damage the valve. Many power-plant fires started from fluids being drained from the power plant, for example, following a shut-down or a hot start; such fluids could be easily and safely drained overboard in a pod installation.

Discussing the performance aspect of pod installations, Mr. Schairer said that, in contrast with buried engines requiring long inlet and tailpipes, the inlet and tailpipe losses in pods were negligible. It was relatively easy to design an isolated pod with a critical Mach number in excess of 0·9; to avoid major interference effects, the location of the pod

in the velocity field below the wing had to be determined experimentally. The fairing of the back end of the pod and the intersection with the mounting strut could have a large effect on basic drag and critical Mach number, but it was possible to obtain an installation giving a negligible loss. Thus the aircraft performance was affected only to the extent of the additional basic pod flat-plate drag—about 18 per cent. Since, however, the pod installation was usually associated with a thin wing of higher aspect ratio and wing loading than an aircraft with submerged engines, and was accompanied by a smaller tailplane, the net result was an unusually high lift-drag ratio, and the greatest capability for long range. The outboard pod-mounted engines resulted in a considerable reduction in positive wing-bending moment, but in general he thought that there was little evidence that pod mountings had a significant effect on the "structural performance," i.e. the ratio of take-off weight to empty weight.

An unexpected result of pod mountings had been the beneficial effect of the outboard pods, which were near the wing tigs, on the stalling characteristics of a highly swept-back aeroplane. They were more effective than any fence or slot; the reasons for this were not understood. Other advantages claimed for pods were that the fuselage lay ahead of the cone of noise from the engines, and that, with reverse jet thrust in operation, the basic wing structure was clear of hot exhaust gases.

In the discussion which followed, most of the British contributors took the view that the high aspect-ratio highly loaded pod wing obtained its excellent long-range characteristics at the expense of take-off and landing speeds, and that the use of wings of greater area and depth, in which the engines could be submerged, made for a more flexible performance both at low speeds and at high altitudes.

Helicopter Power Plants.

In a paper entitled "Power Plants for Rotary Wing Aircraft," Mr. A. Graham Forsyth surveyed the possibilities of turbine and jet propulsion for helicopter drives. The piston engine, he said, still had a place in the small machine, and he thought that a flat 12-cylinder engine, in place of the currently-used radial type, would be more easily installed. For large helicopters, he favoured the gas turbine, with its low weight-to-power ratio and frontal area. The major problem in applying a gas-turbine drive to mechanically-driven rotors was the fact that the turbine could not develop power at low speed. This disadvantage could be overcome either by the use of a fluid clutch or by adopting a free turbine for the final drive, which would allow the rotor drive to be taken up gradually without overloading the engine.

The large helicopter of the future would, he thought, employ jet drives at the rotor blade tips, eliminating torque and gear loads and enabling a high percentage of power to be developed in the rotor. Part of this gain was lost, however, by the extra power needed to lift the extra fuel required by the high consumption of the jets at take-off and hovering.

Three tip-jet-drive systems had been developed—(i) by burning fuel in a power unit mounted on the blade, (ii) by generating compressed air, or compressed air and heated gas, outside the rotor and ducting it through the hub, and (iii) by the "pressure jet," a combination of the first two methods. In the first category, the ram jet was the simplest, but it had a fuel consumption of 8 lb. to 9 lb. per horse-power per hour; with supersonic rotors, however, its efficiency would improve. The pulse jet had a lower consumption of about 6 lb. per horse-power per hour, but was difficult to mount owing to its length. The valve had a short life, and the unit could not be restarted with the rotor spinning; also, it had a high noise level, and was not attractive for rotor propulsion. There remained the possibility of installing conventional jet engines at the blade tips of large rotors.

The second system, in which heated gas was supplied through large ducts in the blades by gas generators, should give, in theory, a fuel consumption of 1·2 to 1·3 lb. per horse-power per hour, and a low noise level; it required no fuel pipes or ignition leads from the blades to the combustion chamber. In practice, however, the main engine had to develop 2,000 h.p. in order to obtain 1,000 rotor horse-power; to conduct the hot gases, a complicated heavy blade construction unsuitable for high-speed rotors would be required, and for take-off afterburning in the jets would be necessary, raising the noise level.

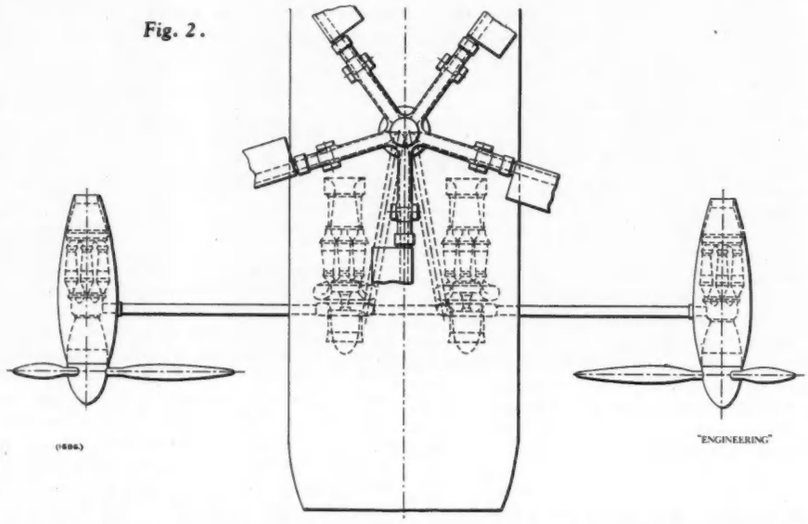
The pressure jet, which was much smaller than other types, had an advantage when reasonable forward speed and take-off at heavy loads was required. The noise level, although high, was much lower than that of the pulse jet, and experiments indicated that it could be reduced acceptably. By controlling compression ratio and mixture strength, a fuel consumption of 24 lb. per pound thrust per hour could be achieved with an effective rotor horse-power equal to the engine power, or 1·8 lb. if the rotor horse-power was 0·75 times engine power. A pressure jet, 7·7 in. in diameter, could develop 500 h.p. The lecturer then described the Fairey jet-powered Gyrodyne, in which air was supplied to tip jets by a centrifugal compressor driven by an Alvis Leonides piston engine. Bevel drives from the gearbox were taken to outboard pusher propellers, which were driven continuously, and to the supercharger, which could be coupled to the engine through a fluid clutch. Yawing control was by varying the differential pitch of the propeller.

Among various schemes for a large civil helicopter, the lecturer favoured an installation in which two 1,200-h.p. gas turbines mounted on top of the fuselage, were used to drive compressors through starting clutches or free turbines. The installation is illustrated in Figs. 1 and 2, above. Outboard units, each comprising a gas-turbine engine without a compressor, drove 1,000-h.p. propellers. The two compressors were each connected through throttles to the rotor head, and to a common inlet to the plenum chamber of the outboard units. Thus, high-pressure air could be directed to any of the units. At take-off, most of the air from both engines supplied the blade-tip jets, the remainder being delivered to the propeller units for yawing control. In forward flight, the required propeller power could be provided by one engine only; the rotor could auto-rotate, or, for maximum forward speed, air from the second engine could be used in the blade-tip jets. The layout was simple and light in weight compared with the mechanically-driven rotor.

GAS TURBINES FOR HELICOPTERS.

Fig. 1.

Fig. 2.



The lecturer concluded his paper with a description of the French cold-air jet drive as fitted to the S.N.C.A.S.O. Djinn helicopter. The noise level was greatly reduced, but the use of cold compressed-air jets resulted in a sacrifice of engine power; a 300-h.p. turbine would be required to drive a 100-h.p. rotor, and the fuel consumption would be about 3 lb. per horse-power per hour.

The choice of power plants for helicopters was also considered in a paper on "Some Factors Affecting Helicopter Design and Future Operations," by Mr. R. H. Miller. In contrast to Mr. Forsyth, this speaker preferred, for the transport helicopter, a gas turbine mechanically coupled to the rotor rather than the pressure jet or turbo-jet drive, which he considered too costly in fuel consumption and suitable only for very short duration. Among other topics discussed in this paper were the possibilities of increasing helicopter cruising speed by the use of rotors with offset hinges, whereby stalling of the retreating blade could be avoided; or by the use of supersonic rotors, which were particularly adaptable for small multiple-rotor configurations.

Price Calculator.—Parion Products, Ltd., Witham, Essex, have issued a new type of price calculator for pricing work or products on the basis of labour and material costs plus overhead charges and profits. It consists of a nomogram inscribed on a metal plate, which is used in conjunction with a graduated plastic ruler, giving an overall accuracy within 1 per cent.

Tin-Plate and Terneplate Prices Stabilised.—The Minister of Supply, after consultation with the Iron and Steel Board, has made an Order affecting tin-plate and terneplate prices. It increases the basic prices for tin-plate and terneplate by 1*s.* 8*d.* per box and 6*d.* per box, respectively, and for the appropriate extras by corresponding amounts. In consequence of the price charges resulting from the operation of the "automatic variation adjustments" for tin and lead, the maximum prices for tin-plate and terneplate will remain unchanged. The purpose of the Order, which has been made on the recommendation of the Iron and Steel Board, is to continue temporarily the stabilisation of the maximum selling prices of tin-plate and terneplate pending further examination of these prices by the Iron and Steel Board. The Order, the Iron and Steel Prices (No. 5) Order, 1953 (S.I. 1953, No. 1438), came into operation on October 1 and is on sale at H.M. Stationery Office.

THE BRITISH ASSOCIATION MEETING IN LIVERPOOL.

(*Continued from page* 423.)

CREEP RESISTING STEELS.

ON the final day of the meeting, Professor W. J. Kearton occupied the chair in Session A and the first paper taken was one on "The Design of Creep-Resisting Steels," of which Mr. E. W. Colbeck, Dr. J. R. Rait and Mr. J. O. Ward were joint authors. The paper, which will be reprinted in an early issue of ENGINEERING, was presented by Mr. Ward.

The first speaker in the discussion on the paper was Major P. L. Teed, who said his particular concern was the application of the work described to the airborne gas turbine, in which it was of great importance. Anything that could be done to reduce fuel consumption had a great effect on the ultimate performance of aircraft and to increase the temperature at which the engine could operate would have the effect of reducing the fuel consumption. Some years ago he had carried out brief experiments himself, but had been discouraged by the fact that he was never able to reproduce them. He would like to have the authors' comments on reproducibility. They had shown some nice smooth curves but had not shown the points through which the curves had been drawn. Primarily, he said, he had been concerned with light alloys and it had been observed and confirmed that the piston alloy in use 15 years ago had better creep resistance than the same alloy in use to-day. The microstructure was substantially the same, but it was generally accepted that 15 years ago the melting of the light alloys was carried out with less technique than it was at present, with the consequence that the amount of aluminium oxide was high and the better creep characteristics of the older material arose from the oxide which, presumably, was located in the alloys. Another point which arose from the paper was that coarse grain was definitely superior to fine grain, but it seemed from what Mr. Ward had said that, with the ferrous materials, the reverse would be the case.

In his reply, Mr. Ward said, with regard to reproducibility, that in general in the laboratory they thought they were doing quite well if they could reproduce a curve to within 5 per cent. at any point, including the fracture time. In the case of the curve, Fig. 1, of the paper the tests occupied 21,250 hours and all the recorded points fell within the thickness of the line. On another similar test they would be very satisfied to achieve reproduction to within $\pm$ 5 per cent.

The next speaker, Mr. G. L. Bailey, said the part of the paper which interested him particularly was that dealing with the attempts the authors had made to understand the kind of structure needed to aim at in order to get a creep-resisting material, and he noted that all the really good creep-resisting materials were non-ferrous metals and not steels. On the question of reproducibility he said a great deal of highly accurate creep measurement was done with highly sensitive equipment on materials which, in his view, could not be repeated on different batches, made, perhaps, in different places, to closer than 20 per cent. In his opinion, Table III of the paper, which gave the results of the measurement of total plastic strain for 1,000 hours and the effects of the vanadium : carbon ratio on that particular steel with two different heat treatments, showed substantially that it did not have any effect at all, because the differences shown in the normalised material which had not been tempered were not significant.

Mr. Ward, in reply, said there was considerable scatter of the results and they did not yet know enough about interference effects. The work they were doing was beginning to show how all the alloys behaved, but, so far, they had only dealt with the effects of one variable at a time; for instance, when chromium was present, the vanadium did not behave as it should do. Too little work had been done on variations of composition; it had a serious effect, but on the whole he thought they had carried out sufficient tests to be fairly sure of the trends. He did not claim that these were more than trends; when they said that one steel had a creep resistance of 10 and another of 20, the truth would be within $\pm$10 per cent., but if the results of two tests were 10 and 11, respectively, they could not argue on the results except when dealing with a whole series. They were not claiming absolute measurements and could not make such a claim until they knew everything about creep.

The only other speaker, Dr. J. S. Forrest, asked whether the authors had used statistical methods in assessing the significance of the figures, and Mr. Ward replied that they had not done so hitherto, but they did intend to employ that technique. Their branch had only been working for about five years, and they were just beginning to get enough material for a statistical investigation. With regard to published results, there was a great lack of systematic work on composition, although there was a considerable amount on heat treatment, particularly Glen's results. In that case there was sufficient information not to need a statistical approach.

At this point, the chairman said the time available had elapsed, and suggested that any further questions should be submitted in writing. He proposed a vote of thanks to the authors, which was carried by acclamation.

TITANIUM.

When the session was resumed after the adjournment, Professor Kearton invited Major P. L. Teed to give his paper entitled "Titanium: a Metal of Engineering Importance?" which we hope to reprint in an early issue.

The first speaker in the discussion on the paper was Professor H. O'Neill, who asked if the author could explain why titanium welded so easily and why the "picking-up" on dies, etc., was such a trouble. In replying, Major Teed said he could not give the reason for picking-up, but methods of preventing it had not been really successful. Different oxidation treatments, which had at once suggested themselves, had not succeeded.

Mr. D. L. Bailey, who followed, said he could detect a much more optimistic outlook on the part of the author regarding the possible uses of titanium, even at current prices, than he had noticed when he had heard him speak previously on the subject. Referring to the possible uses of titanium in industries other than the aircraft industry, Mr. Bailey said its corrosion-resisting properties were fantastically good in some respects. The sea-water corrosion resistance was most imposing, which made it desirable to see the metal used for such items as condenser tubes in H.M. ships.

In reply, Major Teed said, regarding his increased optimism, that on the last occasion Mr. Bailey had heard him speak he had been addressing aeronautical engineers on the application of the metal to airframes, where very little could be done, but on carrying his analysis into aircraft engines he had entered a much more rewarding field. In agreeing regarding the possibility of using titanium in naval condensers, Major Teed said he thought that a tube which would allow water passage at the rate of 40 ft. per second would permit a condenser to be made of much smaller volume and he believed that in certain classes of naval vessels that would be regarded as a great improvement.

The next speaker, Wing-Cmdr. T. R. Cave-Browne-Cave, while agreeing with the suggestion for the application of titanium to condenser tubes, pointed out that the use of a metal as resistant to sea-water corrosion as titanium would lead to a radical change in the design of condensers. With a thin material which was really proof against corrosion, the condenser would probably more nearly resemble the type of heat exchanger used for the radiator part of an aircraft in which the metal surfaces were of paper thickness. At Southampton they had made an experimental condenser rather on those lines, and, disregarding for the time being the problem of corrosion, had obtained rates of condensation per unit block volume three times greater than with the conventional Admiralty design. The Admiralty, however, quite rightly, had been a little doubtful regarding the use of thin alloys in any form in which they would be liable to serious failure by sea-water corrosion. Except for the problem of corrosion there was no doubt that the size of condensers could be greatly reduced, and it was quite possible that Major Teed's titanium alloys might very soon make that kind of development practicable. It should be borne in mind that in the early stages of the introduction of aluminium, and later of magnesium, the price per pound of the metals and their alloys had been enormous, but had decreased as the materials were more widely used. If the price of titanium and its alloys decreased in a similar manner, the picture Major Teed would present when he next spoke on the subject would be still more promising.

Major Teed replied that in his opinion the price would come down. American firms had started propaganda to indicate that there could be no price reduction for the next three years, but, on the other hand, the sole producer in this country had said that the halving of the price was quite possible within three to five years. At the present time, titanium was produced by a batch process and such processes were always expensive. There was now working in America, however, a modification to the Kroll process, which was disappointing to the inventor, who had declared it to be a continuous method of producing titanium, but it seemed that the process would run for very much longer periods when the troubles always experienced by pioneers had been overcome. In spite of the propaganda against a reduction in price, Major Teed was of the opinion that it would come.

The last speaker was the chairman, who referred to another application of titanium as a substance, rather than as a metal, of engineering importance. He recalled the fact that attempts had been made in America to generate power with increased thermodynamic efficiency by the use of a combination of mercury and steam, mercury vapour being used as the high-temperature working substance and steam as the low-temperature substance. The practical difficulties of the process, he said, had all been confined to the mercury boiler, mainly because it was extremely difficult to transfer heat from the steel tube containing the mercury to the mercury itself, owing to the fact that the latter did not wet the steel as water did. Another difficulty was, that at the temperatures used, the steel was dissolved by the mercury in the course of time. These troubles were now being overcome by the addition of extremely small quantities of powdered titanium to the mercury as it circulated through the boiler and the plant. In the first place, the titanium inhibited the solution of the steel and in the second place it enabled the mercury to wet the steel tube and so permitted far greater rates of heat transmission to be employed.

In reply, Major Teed said the chairman had revealed a most interesting fact; the addition of titanium to the mercury in a mercury boiler was an entirely novel idea to him. One of the drawbacks to the use of titanium in the past had been the fact that there was virtually no use for the scrap produced and it might be that the chairman had disclosed one.

The meeting concluded with a vote of thanks to Major Teed, proposed by the chairman.

(*To be continued.*)

BIBLIOGRAPHY ON WOOD AND ITS RELATION TO FIRE.—The Joint Fire Research Organisation have issued a list of references to literature on wood and its relation to fire, including fire-retardent treatments. Copies of the bibliography may be obtained from the Director, Fire Research Station, Boreham Wood, Hertfordshire.

VOLTA RIVER PROJECT, GOLD COAST.—The Volta River Project for exploiting natural deposits of bauxite in the Gold Coast is expected to cost about 140,000,000*l.*, part of which will be lent by the United Kingdom Government and part raised by the Gold Coast National Assembly. A delegation of members of the Assembly, under the leadership of the Hon. K. A. Gbedemah, the Minister for Commerce and Industry, has recently completed a tour of mines and rolling mills in Canada and the United Kingdom in order to assess the likely impact of such a project of industrialisation on a predominantly agricultural people. On the report of the delegation may depend the acceptance or rejection by the National Assembly of the project, notwithstanding the favourable technical and economic recommendations that have been made by the consultants, and by the sponsoring company, the British Aluminium Co., Ltd., St. James's-square, London, S.W.1.

PERFORMANCE OF JAW CRUSHERS.

Fig. 1.

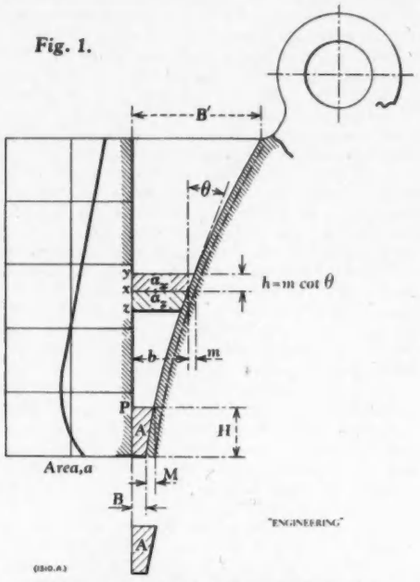


Fig. 2.

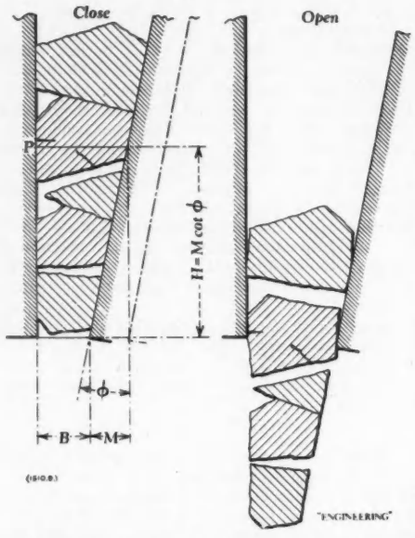
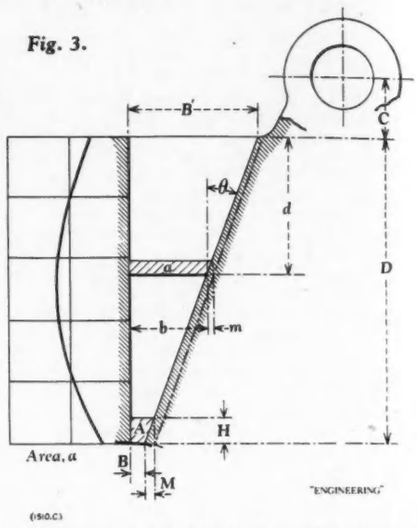


Fig. 3.



THE PERFORMANCE OF JAW CRUSHERS.

By K. Gauldie.

The largest fragment which can emerge from the hopper of a jaw crusher has a thickness equal to the distance apart of the jaw tips when the moving jaw is at the limit of its backward stroke. When the jaw is in the extreme forward position, fragments of that thickness will occur at the level P (Figs. 1 and 2, herewith), where the hopper breadth is equal to the distance apart of the jaw tips when the moving jaw is in the fully-open position. Everything below that level will be of smaller size; and, provided that the duration of the backward stroke is sufficient for material to fall from rest through the full distance H, all the material below the level P will emerge from the hopper when the jaw is retracted. If the crusher is running at moderate speed (that is, if time is not a limiting factor), the area of the wedge of crushed material which emerges during each backward stroke of the jaw is, therefore, the area, A, between the level P and the outlet level, when the moving jaw is in the fully-forward position.

At higher hopper levels within the zone where crushing occurs, the processes are the same as at the hopper outlet except that material which has been nipped at any level, x (Fig. 1), when the jaw was in the forward position does not emerge from the hopper, but falls to the lower level, z, and is arrested there; and the material which was caught at the higher level, y, drops to the level x. In other words, the material which will descend past the level x during a back stroke of the jaw is contained within the boundaries of the wedge which lies between the levels y and x, when the jaw is in the forward position; and, similarly, the material which will descend past the level z during the backward stroke of the jaw is that material which, when the jaw was at the forward limit of its stroke, was contained within the boundaries of the wedge $x\,z$.

During a back stroke of the jaw, the material descends to a lower level and may or may not become more loosely compacted. During a forward stroke, no change occurs in the general level; and the material contained between the levels x and z, is compacted to the area, a_z, of the wedge $x\,z$. At the end of the preceding forward stroke that same material (and therefore the same mass of material) was contained in the wedge $y\,x$, of which the area is a_x. As the two wedges are of the same length L (where L is the width of the hopper), it follows that $L\,\delta_z\,a_z$ is equal to $L\,\delta_x a_x$, where δ_z and δ_x are the mean densities of the material contained in the respective wedges.

The same equality applies for all levels. The basic equation of the jaw crusher is, therefore,

$$\delta a = \text{constant}, \qquad . \quad . \quad (1)$$

and, if the area of the wedge which descends, per stroke, past any level, and the mean density of the material contained in that wedge should be known, the output, per unit of time, of a crusher discharging at uniform rate would be calculable from the equation:

$$w = n\,L\,\delta\,a, \qquad . \quad . \quad (2)$$

where n is the frequency of oscillation of the jaw.

There is, of course, a practical limit beyond which fragmented material cannot be compacted by pressure; and one of the conditions which must be satisfied in any crusher is that the mean density of the emergent material must always be appreciably less than the density of the solid material. Should that condition not be satisfied, forces impossible to endure would be developed; and either the motor must stall, or some part of the machine must yield or break.

Provided that the ratio of the sectional areas of the prisms which descend past the nip and other levels is such that the mean density of the crushed material cannot anywhere exceed the practical limit, the flow of material to the hopper may be unrestricted; that is, the machine may be choke-fed. Under such conditions, it is the mean density with which the feed arrives at nip level, and the area of the prism which descends per stroke past that level, which govern the output and are the appropriate basis of its calculation.

At the hopper level where the larger pieces comprised in the feed are first nipped, only one layer of these lumps can be accommodated between the crushing surfaces. The proportion of voids in the material as it arrives at the nip level, where crushing commences, may, therefore, be appreciably higher than in a pile. The proportion of voids would, of course, vary according as the interstices between the larger lumps were or were not filled with undersized and sandy material. No serious error would be made, however, in estimating the output rate of a crusher if the proportion of voids in the material arriving at nip level were assumed to be 50 per cent. and if the mean density of that material were assumed to be half that of the solid material.

If, however, the ratio of the sectional areas of the prisms which descend per stroke past the nip and any lower level should be such that overcompacting could occur at that lower level if the machine were choke-fed, the mean density of the material arriving at the nip level would have to be under control. Under such conditions of operation the output rate of the machine would, of course, be equal to the controlled input rate and would be greatest if the rate of feed were so regulated that, at the outlet or other level where the "area of descent" is least, the fragmented material would be consistently compacted to the practical limit. In such case it is the least "area of descent" and the maximum practical density to which the fragmented material may be compacted by pressure that govern the greatest output per stroke and are the natural basis of calculation. That maximum density will naturally vary with the material being crushed; but no great error would be involved if it were assumed as four-fifths of the density of the solid material.

Minor errors neglected, the area of the wedge, $y\,x$, which, in a machine operating at low speed, would descend per stroke past the level, x (Fig. 1) is:

$$a = \left(b + \frac{m}{2}\right) h = \left(b + \frac{m}{2}\right) m \cot \theta, \quad (3)$$

where b is the hopper breadth, m is the horizontal component of jaw movement and θ is the angle included between the jaws when the moving jaw is in full forward position, all at the level x.

The corresponding "area-of-descent" curve may be plotted from measurements taken from a layout of the crushing surfaces at close and open settings. For machines of the kind in which the moving jaw swings on a fixed pivot, however, the area-of-descent curve may be plotted from a layout at close setting only. In that case, the hopper breadth, b, and the angle, θ, are measured from the layout, and the horizontal component, m, of jaw movement is calculated.

The jaw oscillates through the small angle, β (Fig. 4); and the movement of a point on the moving jaw surface at distance d below the receiving opening and at distance r from the pivot axis is $r\beta$. The horizontal component, m, of that movement is:

$$m = r\,\beta \cos \alpha = (r \cos \alpha)\,\beta = (C + d)\,\beta$$

At the hopper outlet, the corresponding horizontal component is:

$$M = (C + D)\beta,$$

whence

$$m = \frac{M\,(C + d)}{C + D}, \qquad . \quad . \quad (4)$$

PERFORMANCE OF JAW CRUSHERS.

Fig. 4.

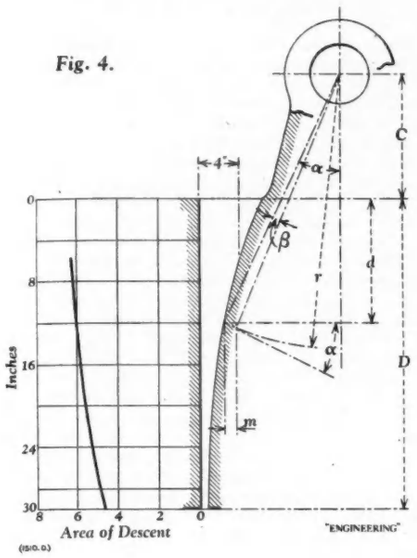


Fig. 5.

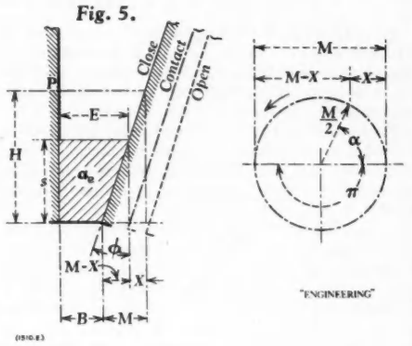
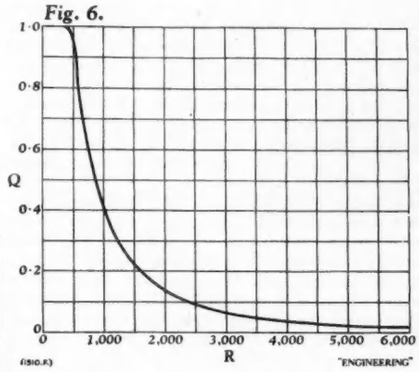


Fig. 6.



and

$$\beta = \frac{M}{C + D} \text{ radians} = \frac{57{\cdot}4\,M}{C + D} \text{ deg.} \quad . \quad (5)$$

The area-of-descent curve, plotted according to equation (3), is useful as providing a general indication of the manner in which the mean density of the material varies as it moves step by step down the hopper of a primary crusher, and for predicting the reaction of the machine to different sizes and kinds of feed. The typical examples plotted in Figs. 1 and 3 for convex and straight jaw-plates, respectively, indicate that, as a rule, the area of descent in primary crushers of the overhead fixed-pivot kind is relatively low at the receiving opening, rises to a maximum at some intermediate level, and thereafter decreases towards outlet. It may be assumed, therefore, subject to check, that the output rate is limited only by the conditions at the nip and outlet levels.

The area of descent at nip level is a special case to which equation (3) does not apply. In any calculation of output rate, it must be assumed that the larger lumps comprised in the feed are all of the same known thickness, and that the stream of material arriving at nip level is of that thickness. The prism of unorushed material which descends per stroke past nip level differs, therefore, from the wedges which descend past all lower levels in that it is rectangular in section. The distance of descent past any lower level is limited by the thickness of the trailing end of the wedge. At nip level, however, that distance is limited by the thickness of the leading end of the rectangular prism, that is, by the thickness of the larger lumps comprised in the feed. In the special case at nip level, the distance h_f, through which material may descend per stroke, corresponds, therefore, to the distance xz (Fig. 1) and not, as at lower levels, to the distance yx.

The area of the rectangular prism which descends per stroke past nip level is, therefore

$$a_f = h_f b_f, \quad . \quad . \quad . \quad (6)$$

where b_f is the one-way size of the larger lumps comprised in the feed and is equal to the distance apart of the jaws at nip level when the moving jaw is at the forward limit of its stroke, and where h_f is the distance of descent measured downwardly from nip level; that is,

$$h_f = m_f \cot(\theta_f - \beta), \quad . \quad . \quad (7)$$

where m_f is the horizontal component of jaw movement at nip level, θ_f is the angle included between the jaws at that level when the moving jaw is in full forward position, and β (see equation 5) is the angle through which the jaw oscillates.

It has so far been assumed that the duration of the backward stroke of the jaw is sufficient for material to fall from rest through the full distance H (Fig. 1). The duration of the return stroke decreases, however, as the frequency of oscillation of the jaw increases; and, as the speed of a crusher is increased from zero onwards, a "critical speed" is reached at which material immediately above the level P (Figs. 1 and 2) has just had time to fall through the distance, H, has just regained contact with the moving jaw, and has just been arrested between the jaw tips when the moving jaw is at the limit of its backward stroke.

As speed is further increased, time becomes the factor on which distance of descent past hopper outlet depends. At speeds above the critical, that distance is proportional to the square of the time available for descent and tends, consequently, to be inversely proportional to the square of the frequency of oscillation of the jaw. At speeds above the critical, the height of each emergent wedge tends, therefore, to vary inversely as the square of the jaw frequency and to decrease rapidly as the speed is increased. The number of wedges emerging per unit of time, however, is directly proportional to the speed of the machine. The total volume of the emergent wedges discharged per unit of time by a crusher when its speed is increased above the critical tends, therefore, to decrease in proportion as the speed increases.

Were the time available for descent no more than the duration of the backward stroke of the jaw, the volume of material discharged from the hopper would reach a sharp maximum at the critical speed and thereafter would decline as the speed was further increased.

At speeds above the critical, material descending from rest has not had time, however, in the duration of the return stroke, to regain contact with the moving jaw tip when the jaw is at the limit of its backward stroke; and the jaw has moved some distance through its forward stroke before it regains contact with the material rapidly descending past the hopper outlet. The time available for descent is greater, therefore, than the duration of the return stroke if the crusher is running at super-critical speed; and the distance of descent, and the area and volume of the emergent wedges, are therefore greater than would be the case if only the duration of the return stroke were available for descent.

For that reason, the total volume of material emerging per unit of time from the machine does not reach its maximum at the critical speed but goes on increasing at a diminishing rate until a maximum is attained, after which the output rate, by volume, declines as the speed is further increased.

Output rate in terms of weight does not, however, in general begin to taper off immediately the critical speed is exceeded. The same mass of material may continue to descend per stroke past the nip level. A decrease in the volume of material discharged may be offset, therefore, by an increase in the mean density of that material; and the output may continue to be proportional to the speed over a considerable range beyond the critical speed.

Material starting from rest at the beginning of the backward stroke of an eccentric-driven crusher would fall the distance, S, to outlet level in the duration, t, of that stroke, where:—

$$S = \frac{g\,t^2}{2} = \frac{g}{8\,n^2}.$$

When the machine is running at its critical speed, n_c, the distance, S, is equal to the height, H (Figs. 1 and 2); that is,

$$H = \frac{g}{8\,n_c^2},$$

whence

$$n_c = \frac{\sqrt{g}}{\sqrt{8\,H}}, \quad . \quad . \quad (8)$$

or, when the speed is in terms of revolutions per minute and H is measured in inches, the critical speed is

$$N_c = \frac{417}{\sqrt{H}}. \quad . \quad . \quad (9)$$

When an eccentric-driven machine is operated at super-critical speed, the outlet tip of the moving jaw has travelled the horizontal distance, X (Fig. 5), through its return stroke before it regains contact with the material falling through the hopper; and its eccentric has moved through the corresponding angle, α, past its backward dead centre. Free descent has taken place, therefore, during the angular movement, $\pi + \alpha$, of the eccentric.

During this angular movement of the eccentric, the emergent wedge has fallen the distance s, its upper surface has fallen to jaw-tip level, the material below that level has emerged from the hopper, and the material immediately above it has regained contact with the moving jaw and has been arrested.

As the jaw tips are, by assumption, straight for a distance above the outlet at least equal to the height, s, of the emergent wedge, that height, in

TABLE I.

α deg.	0	10	20	30	45	60	75	90	105	120	135	150	160	165	180
Q ..	1·0	0·99	0·97	0·93	0·85	0·75	0·63	0·50	0·37	0·25	0·146	0·067	0·030	0·017	0
R ..	417	440	470	503	562	640	745	883	1,080	1,390	1,905	2,950	4,530	6,130	x

terms of the jaw movement, M, and of the corresponding height, H, is :—

$$s = \frac{H(M - X)}{M}.$$

In terms of the angular movement α, the distance X is

$$X = \frac{M}{2}(1 - \cos \alpha);$$

whence, by substitution in the preceding equation,

$$s = H\left(\frac{1 + \cos \alpha}{2}\right) = H\,Q. \quad . \quad (10)$$

This downward movement occurred while the eccentric moved through the angle $\pi + \alpha$, and took place in the time t, where

$$t = \left(\frac{\pi + \alpha}{2\pi}\right)\frac{1}{n};$$

whence

$$s = \frac{g\,t^2}{2} = \frac{g\,(\pi + \alpha)^2}{8\,\pi^2\,n^2}. \quad . \quad (11)$$

It follows from equations (10 and 11) that :

$$\frac{g\,(\pi + \alpha)^2}{8\,\pi^2\,n^2} = H\left(\frac{1 + \cos \alpha}{2}\right);$$

whence

$$n = \frac{\pi + \alpha}{2\,\pi}\sqrt{\frac{g}{H(1 + \cos \alpha)}}, \quad (12)$$

or, when the speed is in revolutions per minute, the dimensions are in terms of inches, and angles are measured in degrees,

$$N = \frac{1}{\sqrt{H}}\left[\frac{3{\cdot}27\,(180 + \alpha)}{\sqrt{1 + \cos \alpha}}\right] = \frac{R}{\sqrt{H}}. \quad (13)$$

For any particular values of the speed N and the dimension H, there is a corresponding value, $N\sqrt{H}$, of the function R of the angle α ; and for that value of R there is a corresponding value of the function, Q, of the same angle. If, then, a curve of Q plotted against R, as in Fig. 6, is available, the value of Q for any particular values of N and H is obtainable ; whence the height s, of the emergent wedge follows by equation (10) without knowledge of the angle α being necessary.

Table I, on page 457, gives the angular functions, Q and R, from which a Q R curve may be drawn to a convenient scale.

The area of an emergent wedge (see Fig. 5) is

$$a_e = s\left(B + \frac{s \tan \phi}{2}\right) = s\left(B + \frac{M\,s}{2\,H}\right), \quad (14)$$

where ϕ is the angle included between the jaws at the hopper outlet when the moving jaw is in the full forward position.

The mean density of the emergent material, by equation (1), is

$$\Delta = \frac{a_f\,\delta_f}{a_e}, \quad . \quad . \quad . \quad (15)$$

where a_f is the area of the prisms which descend, per stroke, past the nip level and δ_f is the mean density of the material contained in them. Should that area and that density be known, the corresponding output rate would be calculable from the equation

$$w = n\,L\,\Delta\,a_e. \quad . \quad . \quad . \quad (16)$$

This equation, as modified to suit the units of measurement usually employed, takes the form

$$T = \frac{N\,L\,\Delta\,a_e}{K}, \quad . \quad . \quad . \quad (17)$$

where T is the output rate in tons per hour, where the constant K is 64,500 for tons of 2,240 lb. and 57,600 for tons of 2,000 lb. ; where N is the speed of the machine in revolutions per minute and where the mean density Δ of the emergent material is in pounds per cubic foot and the dimensions are measured in inches.

The density of the emergent material depends, however, on the conditions at nip level ; and time may be the factor on which, at that level, as at the outlet, the distance of descent depends.

(To be continued.)

SURVIVAL AT SEA.*

By Sir William Wallace, C.B.E., F.R.S.E.

In 1952, 430,000 passengers were transported by air, and approximately one million transported in ships, across the Atlantic. What chances have the air passengers of survival in the sea should any mishap occur to the aircraft ? Provision is made in the form of inflatable rafts and inflatable lifebelts, and it may be asked what logical argument the authorities can put forward against the provision of similar equipment in a ship on a regular trade route.

In an aircraft the time interval between trouble and landing in the water may be a matter of minutes ; one can hardly visualise an accident to a ship, other than in time of war, which would not give quite a reasonable time to embark the passengers and crew on some form of life-saving equipment. Can we not therefore visualise a modern liner equipped with, say, two first-class power-driven lifeboats, with every modern device for safety at sea, and two emergency lifeboats for use in case of " man overboard," or other similar occasions, but with provisions made for the safety of the remainder of the passengers and crew in modern inflatable equipment as approved by the authorities for survival at sea of aircraft passengers and crew, but at present considered unsuitable for survival at sea of the passengers and crew of a ship ?

It has been proved repeatedly that, despite the fact that ships are equipped with lifeboats for all, after serious collisions heavy listing may take place and frequently the lifeboats on one side of the ship cannot be launched. This condition could hardly arise with a ship equipped with inflatable rafts. I have studied the report on the loss of the Princess Victoria—here was a doomed ship not far distant from shore with lifeboats capable of accommodating all on board. From this report we note that after the order was given to abandon ship not a single lifeboat could be launced from the Princess Victoria by the designed methods, and the report also bore the note " It was not possible to launch boats from any of the rescuing ships." I am confident that if the Princess Victoria had been equipped with air-sea rescue equipment designed and adapted for service on ships the majority of the personnel on board would have survived. At the present time these inflatable dinghies have been designed for dropping overboard from a ship or aircraft in distress, and the passengers must depend temporarily for their survival on the use of a lifebelt, which supports them until they can be taken on board the dinghies. There is nothing whatever to worry our designers in the provision of equipment which would enable these rafts to be inflated on board and lowered into the sea with all personnel on board and with the usual emergency equipment installed. Ships to-day are in constant communication with the shore and with other ships ; following a collision or similar disaster, the ship's position is known, and with all the personnel safely afloat in rafts, in conditions under which the weakest should survive, help should soon arrive.

Rafts have few facilities for manœuvring compared with a lifeboat, which can, with a skilled crew, be kept steering a course to some known destination, but we have the advantage that the modern raft can be quickly launched and float safely without any skilled people on board—a practically unsinkable support which can ride through all weather conditions quite safely, free from risk of capsizing, pending the almost certain arrival of rescue ships. In the case of the Titanic these rescue resources were available within a few hours of the sinking of the ship. It is well known that with the best of lifeboats the conditions on board are difficult in heavy or cold weather and many of the rescued have died from exposure. At the Engineering Exhibition at Olympia I examined a ship's lifeboat with an aluminium hull and the usual lifeboat fittings. This lifeboat, with a small engine, had been navigated from Oslo to London under sail and power in ten days. A sturdy boat, but the accommodation was such that I could not imagine any but the hardiest of the 44 mortals it is designed to carry surviving for any length of time in this most inadequate, uncomfortable accommodation.

The present inflatable rafts are designed to provide comparative comfort, and with the air insulation of the buoyancy chamber below and a canopy above, it has been proved that even under Arctic conditions the personnel on board can survive. On a test in Arctic conditions with a sea temperature of 35 deg. F., an inflatable raft was manned and in one hour the temperature within the covered raft rose to an extent that necessitated increased ventilation for comfort. In tropical conditions the double canopy provides shade and the open entrances allow a cooling draft of air in the slightest breeze as the raft lies to its drogue. Compare these conditions with conditions in a standard open lifeboat. In heavy weather many lifeboats are smashed before they can be successfully launched, with or without the personnel on board, whereas it has been demonstrated that the inflatable raft can suffer very severe punishment by contact with the sides of the ship. So we come back to the question—has not the time arrived when the ship designer should be relieved of the necessity of making provision for these enormous weights on the boat deck of the ship ? Consider the improvement in the stability of a ship that at present carries on her boat deck a weight of 450 tons if we reduced this weight to approximately 30 tons high up in the boat deck, and carried the remainder of the life-saving equipment on a lower deck, available for instantaneous launching regardless of the conditions in the ship. Rafts could be stowed on both sides of the ship, but it is obvious that as the rafts are light and easy to handle, they could be transferred from one side of the ship to the other should launching conditions be difficult from one side. Certain naval authorities studying the problem have called for rafts designed in shape to resemble boats. Experience has shown that this shape of raft can be capsized : it has yet to be proved that a circular raft can be capsized even in the roughest weather.

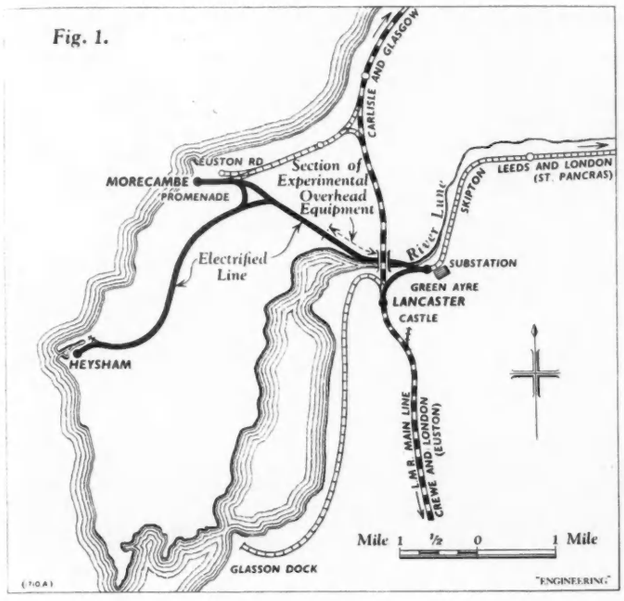
Sea tradition reminds us that the captain is always the last to leave his ship, and that tradition has repeatedly resulted in the loss of a valuable navigator. Surely the captain's life is valuable and his prospects of survival infinitely greater if he had on his bridge a small raft, light enough to be carried in his hand yet capable of supporting him and his senior officers in the sea until help arrives.

The present design and use of inflatable rafts are based on launching the compact raft in its casing into the sea, where it automatically inflates and is ready to receive passengers taken from the water. I suggest a ship with this equipment would have the rafts stowed away on the most convenient deck, possibly the promenade deck. On the deck head I would install light girders carrying a sliding member from which would be suspended, when required for launching the raft, a light frame with rigid base capable of supporting the inflated raft with all personnel on board. The frame would be suspended just clear of the deck, and after all were on board it would be swung out by one man and lowered from a small hand winch, whose only function would be to lower the raft on the brake and recover the frame ready to launch further rafts—a one-man job. The frame would be arranged with a quick release on one support of the base, allowing the raft to float clear of frame and ship. As the rafts in an emergency could be thrown overboard and embarked from the sea, requirements might be met by providing such launching equipment, say one for each three rafts carried, and on this assumption the following weights are based.

Let us look at the estimated weight of the equipment now suggested as compared with the regulation lifeboat equipment installed on an Atlantic liner carrying approximately 3,200 persons. The lifeboats, davits and recovery winches weigh approximately 450 tons, carried in the highest part of the ship. A fair estimate of the weight of two power-driven lifeboats, each capable of carrying 145 persons with complete equipment, and two emergency boats each capable of carrying 35 persons, all boats carried in gravity davits with recovery winches, would be 30 tons ; 142 inflatable rafts, each accommodating 20 persons, represent a weight

* Presidential address to the Institution of Engineers and Shipbuilders in Scotland, delivered in Glasgow on Tuesday, October 6, 1953. Abridged.

50-CYCLE ELECTRIFICATION OF LANCASTER-MORECAMBE-HEYSHAM LINE.



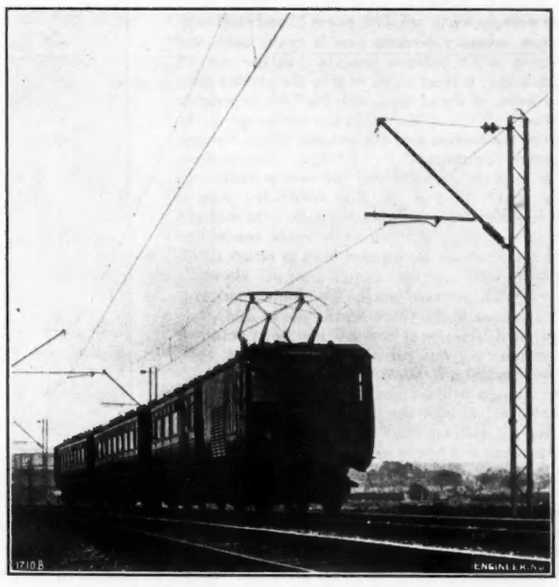


FIG. 2. THREE-COACH SET.

of approximately 10 tons. The estimated weight of 48 sets of launching equipment is approximately 24 tons, and allowing, say, 5 tons for stowage accommodation for the rafts, we have 30 tons of equipment on the boat deck; and at convenient positions lower down in the ship 39 tons—a spread total weight of 69 tons against the 450 tons on the boat deck to be carried around the ocean during the life of the ship. Surely any proposal showing such a large weight saving in the most vital part of the ship requires the most careful consideration.

One criticism—will this inflatable equipment be available when required? It is comparatively simple to arrange for regular inspection. A compartment can be set aside and arrangements made under which all life-saving equipment can be air-tested at frequent intervals on board, and the CO_2 cylinders (used for automatically inflating the equipment) tested by simply checking the weight of the charged cylinder. How does the cost of this maintenance compare with the cost of maintenance of existing lifeboats? Not only the lifeboats but all equipment—winches, tackle, etc.—requires considerable maintenance, painting for preservation, etc., and under the classification society rules it is necessary, at regular intervals, to remove all the buoyancy chambers and test them. I am sure that the cost of this maintenance must greatly exceed the cost of the maintenance of inflatable equipment.

Existing regulations compel the shipowners to provide lifebelts for the maximum number of persons to be carried on the ship, and it is specified that these lifebelts should not be of the inflatable type using air as the buoyancy medium. Are the lives of the sea-borne passengers any more valuable than the lives of air-borne passengers? In aircraft the authorities permit inflatable lifebelts; why not, therefore, permit similar regulations to govern the provision of lifebelts for sea-going ships? The modern inflatable lifebelt arranged for automatic inflation, and with emergency provision for blowing up by the wearer, is in every way more efficient for support in the best position for survival of the person in the sea, even if unconscious, than any type of non-inflatable lifebelt that has yet been designed. Demonstrations have been carried out proving that with the latest pattern a fully-dressed person wearing a fully-inflated lifebelt can jump into the sea from a height of 32 ft. without suffering harm.

Consider the position if conditions arose necessitating the order "abandon ship." We would hope that at least one of the powerful motor-boats could be launched with a navigating party on board—the lifeboat to be equipped with equipment for towing the rafts. With time available, all rafts would be launched with all personnel on board and stored with the usual equipment as carried in lifeboats under existing regulations, excluding possibly unnecessary navigational equipment. So I visualise all personnel afloat in rafts, one lifeboat safely launched, the captain taken on board from his raft and once again in control of the position, knowing that though his passengers and crew were being tossed about they were under cover and in conditions ensuring their survival. Gradually he gathers his charges together, all rafts finally in tow, the lifeboat steaming slowly ahead to sea, the rafts steadied by their drogues, awaiting the arrival of the rescue ships.

In conclusion, let us recall three instances in which inflatable rafts have figured. I am sure many have read the stirring story of the French scientist Dr. Bombard, who voluntarily sailed alone across the Atlantic, his story providing us with a demonstration that with knowledge and courage one may survive at sea living on the produce of the sea. This voyage, lasting 65 days, was accomplished in an inflatable raft. During the war three American airmen, "ditched" far from sea trading routes, spent 139 days at sea in an inflated dinghy before being rescued. Finally, there was the Icelandic fishing vessel: Atlantic seas smashed the lifeboat and sank the ship, but fortunately she also carried an inflatable raft, and six of the crew of eight who managed to reach the raft were able to paddle it to shore and safety.

In the light of these considerations I feel that we should—nay, it is our duty—very carefully to review our present provisions for life-saving at sea.

REGIONAL ADVISORY COUNCILS FOR FURTHER EDUCATION.—A list of regional advisory councils and local education authorities has been published by the Regional Organisation of Further Education in England and Wales, and may be obtained from the Regional Advisory Council for Higher Technological Education, Tavistock House South, Tavistock-square, London, W.C.1, price 1*s.*, post free.

PRESTRESSED CONCRETE: FILMSTRIPS.—Two filmstrips describing the Freyssinet system of prestressing concrete have been produced and are being sold by Diana Wyllie Filmstrip Production, 18, Pont-street, London, S.W.1. The first strip describes the equipment and its method of use, and the second is concerned with the development and applications of the method. Both strips are accompanied by lecture notes written by Mr. A. J. Harris, B.Sc., A.M.I.C.E.

50-CYCLE SINGLE-PHASE ELECTRIFICATION ON BRITISH RAILWAYS.

WHEN the original rolling stock of the Lancaster-Morecambe-Heysham line reached the end of its useful service in 1951, it was decided to utilise the line as a testing ground for 50-cycle single-phase traction. Experiments had been proceeding on the Continent, and particularly in France, with supplies of this frequency and were yielding good results. British Railways, therefore, in conjunction with the English Electric Company, Limited, and British Insulated Callender's Construction Company, Limited, drew up plans to convert the original 25-cycle supply to 50 cycles and to try out various types of overhead gear. In the meantime, the service was continued using steam traction. A map of the line is given in Fig. 1. Trial runs with the new system were begun late in 1952 and the electric passenger service restored in August of this year. This service will give much useful information for any further main-line electrification, both abroad and in this country, such as was suggested by Mr. R. C. Bond, of the British Transport Commission, in his presidential address to the Institution of Locomotive Engineers, reported in last week's issue, page 439. Earlier references to the scheme appeared in vol. 172, page 659 (1951) and vol. 175, page 12 (1953). On September 29, a special visit was arranged for consulting engineers and representatives of foreign railways and of the technical Press to inspect the system in detail.

This stretch of line, which has a length of about nine route-miles, is a very suitable site for testing overhead gear. It is fully exposed to the westerly winds coming straight off the sea and there is sufficient steam traffic to give a severe trial of the corrosion-resisting properties of materials and finishes. Also, speeds up to 60 m.p.h. can be allowed, which give a full test of the conductor system. The line was first electrified in 1908. Portal frames having wood uprights and steel cross-members were used supporting a simple catenary construction.

When the conversion was begun it was found that most of the original overhead gear was still sound, and was quite suitable for use at the higher frequency. A length of approximately 4,000 ft., between Green Ayre station and Morecambe, was removed and replaced by light, single-track, hinged cantilevers. Seven different types of upright have been installed: rolled-steel joists, steel broad-flange beams, aluminium-alloy broad-flange beams, lattice steel, tubular steel, prestressed concrete and

creosoted wood, and more than a dozen protective coatings have been employed. The cantilever arms and the insulators are also of varying design. Figs. 3 and 4, herewith, show some of these types; others were shown in vol. 175, pages 12 and 16 (1953). A simple catenary construction is again used, and tensioning is by balance weights; in the case of the down line, it is arranged to give the overlap span at the centre of the section, with the balance weights there, and, on the up line, with the anchorage at the centre of the section and the weights where the new equipment overlaps the old. The overlap span can be seen on the left, and the centre anchorage on the right, in Fig. 3. The conductor wire is positively registered at each support. On straight track the catenary is retained over the centre-line of the track while the contact wire is offset 12 in. on either side of the centre-line at alternate supports. On curved track, the contact wire is held tangential to the track centre-line at mid-span. The original voltage of 6·6 kV has been retained for convenience, but all overhead gear has been designed for 20 kV, since it is expected that the higher voltage will be more acceptable for general applications. One of the main objectives has been to make all parts suitable for quick erection, as overhead gear is a costly item in electrification.

The new stock required for the line was drawn from that rendered surplus by the closing of the Willesden-Earls Court line to passenger traffic in 1940. Three three-coach sets which were built by the Metropolitan Carriage, Wagon and Finance Company in 1914 have been used, after conversion at the Wolverton Carriage and Wagon works of the London Midland Region. These units consist of a motor-coach, trailer coach and driving trailer coach. Considerable modification had to be made to the motor coaches to accommodate the new equipment, resulting in reduced passenger accommodation. In future units the gear will be mounted below floor level, but this was not possible with these coaches. Fig. 2 shows one of the units. The current for the whole system is supplied from a new substation built at Green Ayre and replacing the original motor-generator station at Heysham. There are two main transformers, each of 833-kVA capacity, of which only one is normally in use at a time, and the track feeder switches are controlled from the signal-cabin. The single pantograph on the train collects the current and feeds it to the main transformer through a fuse. The transformer has a centre-tapped secondary winding which supplies two rectifiers. In the event of a transformer fault, a relay blows the fuse and lowers the pantograph.

The rectifiers are of the sealed steel-tank mercury-arc type with six anodes paralleled in groups of three. Some smoothing of the direct current is obtained by two series reactors mounted on a common core. Each rectifier feeds two traction motors, connected in series with the mid-point earthed. These motors each develop 215 h.p. at the one-hour rating, this size being chosen to give the desired acceleration. In general design they are similar to those used on the Southern Region. Allowing for a 10 per cent. line drop, the four motors give an output at the wheels of 860 h.p. at the one-hour rating. Speed control is by a cam-operated on-load tap changer working in both halves of the transformer secondary. Additional windings supply the train lighting and heating circuits. The transformer oil is radiator-cooled and the equipment compartment is fitted with thermostatically-controlled electrically-operated shutters which control the flow of air and therefore the cooling of the rectifiers. The units are fitted for multiple operation.

The changeover from 25 to 50 cycles and the installation of rectifiers in the trains caused an increase in the interference on the signalling and telecommunications circuits. It was found necessary to replace the overhead cables by underground cables to overcome this. Similarly, the track circuits were affected by the changes. The stray alternating currents were limited by chokes in the feed end and the relays fitted with a magnetic shunt and copper slugging to make them responsive only to direct current. All are now operating satisfactorily. It is expected that much useful information will be gained from this trial line to assist in designing future installations at home and abroad.

50-CYCLE RAILWAY ELECTRIFICATION.

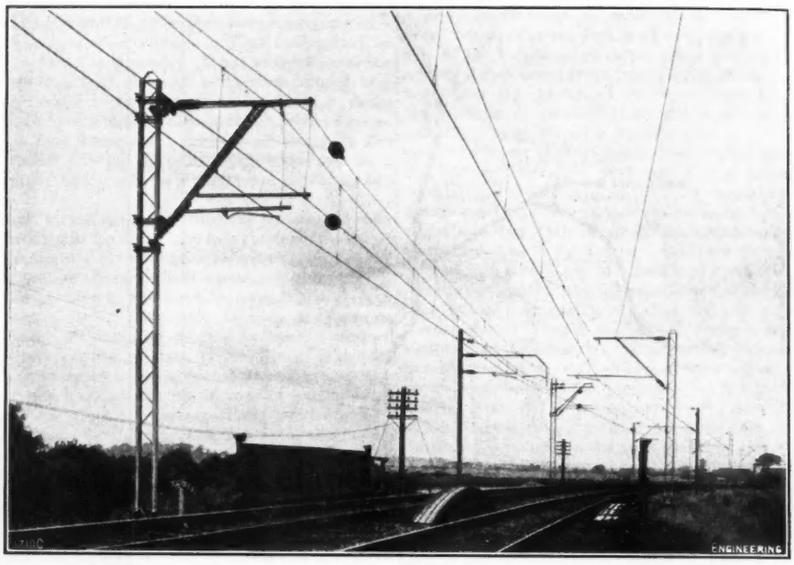


Fig. 3. Lattice and Other Uprights.

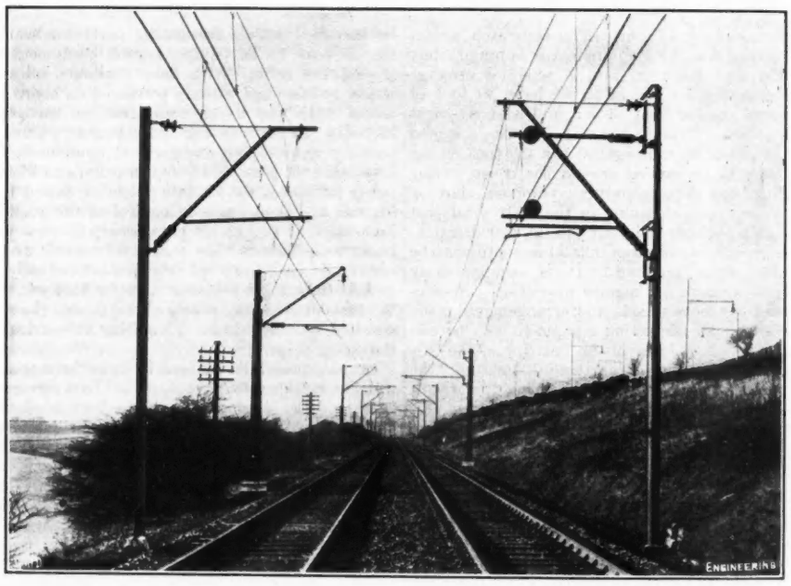


Fig. 4. Rolled-Steel and Tubular Uprights.

TIN-BOX MAKING MACHINERY.

Recent additions to the range of tin-box making machinery manufactured by F. J. Edwards, Limited, 359-361, Euston-road, London, N.W.1, include a trimming press for irregular-shaped pressings, a dual-operation slide press, and a hinge-wiring machine.

Irregular Trimming Machine.

The machine shown in Fig. 1 has been designed for the rapid automatic trimming of light seamless pressings of irregular (i.e., non-circular) form. It is capable of dealing with pressings from 3 in. by 2 in. to 6 in. by 4 in., and from ¼ in. to 1 in. deep, in 30-s.w.g. tin-plate or its equivalent. With special tools it is possible to trim smaller and narrower pressings. The machine operates at a speed of 50 to 60 trimmings per minute, and can be arranged to take its feed direct from the drawing press through a simple inclined chute, or it can be fitted with a hand-filled magazine feed, as shown in the illustration. In the case of the hand-filled magazine, a star-wheel, visible in the illustration, is provided to ensure that the pressings are placed in the magazine with the untrimmed edge facing the trimming tool. This star-wheel enters the hollow part of a pressing which is placed in the magazine correctly, and allows it to pass; a pressing facing in the wrong direction will foul the star-wheel, and will have to be lifted out and turned round before it can slide down to the trimming position. The slides forming the magazine feed are adjustable to accommodate pressings of various widths and depths; the width adjustment can be seen in Fig. 1, and the depth adjustment in Fig. 2, which shows the pressings entering the machine.

At the bottom of the feed magazine, a pressing comes into line with a trim block, which is shaped to fit it, and it is pushed on to the block by a lever, which holds it firmly in position. The trimming tool is then oscillated against the open end of the

TIN-BOX MAKING MACHINERY.

F. J. EDWARDS, LTD., LONDON.

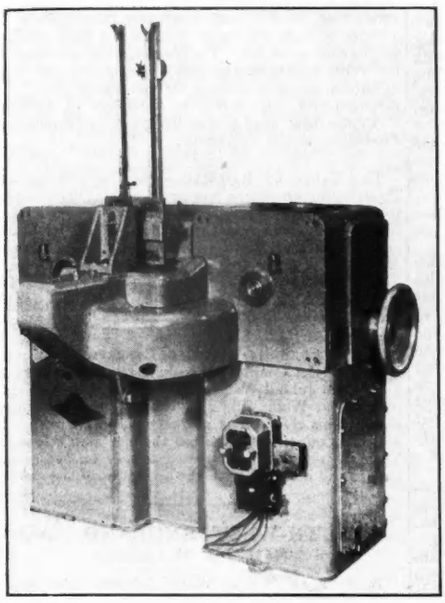


FIG. 1. IRREGULAR TRIMMING MACHINE.

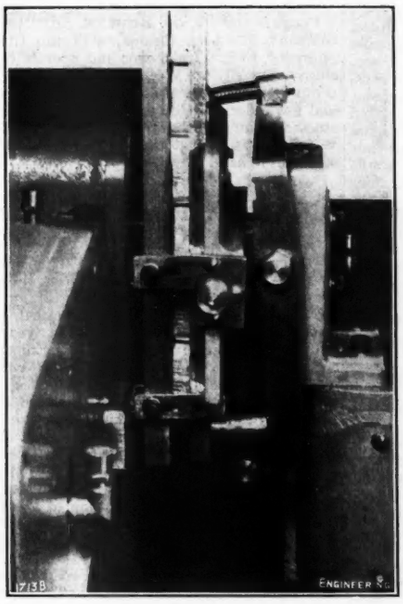


FIG. 2. TRIMMING MACHINE, SHOWING FEED OF BOXES TO HEAD.

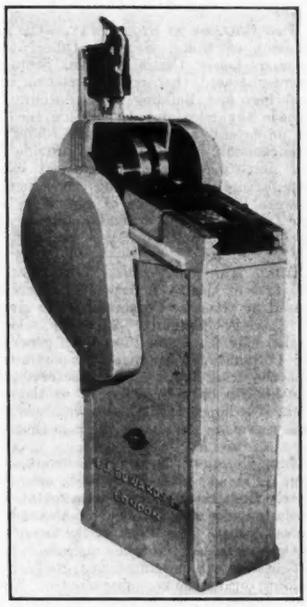


FIG. 3. DUAL-OPERATION SLIDE PRESS.

pressing to remove the rough edge as left by the drawing press. The trimming tool, which is of heat-treated alloy steel, has a special internal contour, which shreds, or breaks up the trimming into four or six small pieces. These fall into a chute leading to the back of the machine, where they are deposited into a container for disposal. The removal of the trimmings as shreds instead of as light, springy rings of material, is an important feature of the machine, since it makes the handling of scrap a simple matter. When the trimming operation is complete, the reciprocating movement of the trimming tool ceases, and an ejector, operated by a push-rod passing through the annular trimming tool and into the trim block, pushes the trimmed pressing off the block, and allows it to fall into a chute at the front of the machine, whence it passes into a container. A stop lever, which is visible in both illustrations, is provided to arrest the downward movement of the pressings in the feed magazine while the trimming operation is in progress.

The machine is driven by a 2-h.p. electric motor mounted in the base, and provided with push-button start-stop control gear, with push-button inching for use when setting the machine. To enable the final setting adjustments to be done by hand, there is a handwheel drive (visible in Fig. 1). This is normally inoperative. To use the handwheel it is necessary to pull it out; this automatically operates a switch which cuts out the drive motor. To set the machine for a different size of pressing it is only necessary to remove the guards, adjust the width of the feed chute or magazine, and change the trim block and trimming tool.

DUAL-OPERATION SLIDE PRESS.

The dual-operation horizontal slide press shown in Fig. 3 is designed for carrying out, in one operation, any two standard opposed operations on a box or similar pressing. Typical operations are: lid bending and beading, or hinge "popping" and beading on opposite sides of a seamless box. The machine can take pressings up to 6 in. by 4 in., of any shape, and larger pressings can be accommodated in certain cases. The operating speed is 45 to 60 strokes per minute, but higher speeds can be arranged with special gears.

The machine consists, basically, of a slide which carries a simple male tool, the slide being mounted at an angle with the horizontal to facilitate hand feeding. At each limit of travel of the slide is mounted a female tool. A pressing is placed, open side downwards, on the slide tool, which is made small enough to accommodate it easily. The slide tool then moves to the limit of its travel in one direction, forms the bead, hinge "pop" or other shape as required against the stationary female tool, reverses its movement, and proceeds to carry out the second operation at the other end of its stroke. The slide tool is reciprocated by means of cams, which give it a travel of ½ in. in either direction, with a pause or "dwell" in the centre of the stroke to allow the pressing to be removed and another one to be placed in position. Both female tools are adjustable in the direction of travel of the slide, and all three tools are easily changed. The tools are all of very simple form, and therefore cheap and easy to make. The machine is driven by a ½-h.p. electric motor mounted in the base, and equipped with push-button control. Lubrication of all bearings is by means of a Benton and Stone "one-shot" lubricator.

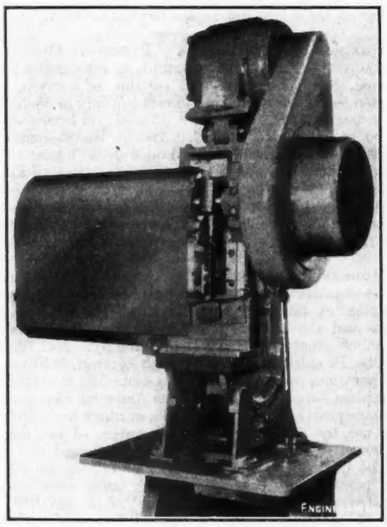


FIG. 4. HINGE-WIRING MACHINE.

HINGE-WIRING MACHINE.

The hinge-wiring machine (Fig. 4) is an adaptation of a small single-crank press, and is designed for use in conjunction with the dual-operation slide press, which produces the hinge "pops" ready for wiring. The hinge-wiring machine can deal with pressings from approximately 1½ in. by 1½ in. to approximately 5 in. by 4 in., the actual limits of size depending on the distance between the hinge "pops."

The pressing to be wired is placed by hand on a shaped block at the front of the machine. This block, which is set at a slight angle to the horizontal, is visible in Fig. 4. The pressing is placed in position with the hinge "pops" at the top. The machine is then set in motion by means of a single-stroke key clutch of the normal type, and a length of wire is fed forward through a tubular guide by a pair of pinch rolls. The wire, which is drawn from a coil mounted on the machine, feeds forward in such a manner that it passes over the top of the pressing until it reaches the right-hand side, where the angle at which the pressing is carried by the block causes the wire to enter the right-hand hinge "pop." A shearing tool then descends, cuts off the wire against the tubular guide, and springs it into the left-hand hinge "pop." The cycle is then complete, and the machine stops, to allow the operator to remove the wired pressing and place another one on the wiring block. The machine is normally provided with a 1-h.p. electric motor mounted on the frame, as shown in the illustration, but it can be fitted with a belt pulley for line-shaft operation if required.

PLATINUM METALS EXHIBITION.—An exhibition illustrating the dependency of modern science and industry on the platinum metals is being held at Grosvenor House, Park-lane, London, W.1, to mark the triple jubilee of William Hyde Wollaston's announcement of his discovery of the precious metal palladium, and is being opened by H.R.H. the Duke of Edinburgh on October 19 next. The exhibition, which is being held under the auspices of the Institution of Metallurgists, 4, Grosvenor-gardens, London, S.W.1, will be open to the public from Thursday, October 22, to Saturday, October 24.

NOTES FROM THE INDUSTRIAL CENTRES.

SCOTLAND.

New College at Stornoway.—The Earl of Home, Minister of State, Scottish Office, when formally opening Lewis Castle College, Stornoway, Lewis, recently, stated that courses relating to local needs, seafaring, and building would occupy a prominent place in its curriculum. In addition, the College marked an important advance in the island's educational arrangements, in that it would provide both full-time and part-time courses in nautical subjects, textile manufacture, and building construction for lads between 15 and 18 years of age. The success of the new facilities would depend upon the support which they received from industry generally.

Trial Run of Former Liverpool Tramcar.—The first of the 24 Liverpool tramcars recently purchased by Glasgow Corporation was given a trial run on Sunday, September 27, over selected Glasgow tracks. Mr. E. R. L. Fitzpayne, general manager of the Corporation's tramways department, said later that the trial had been satisfactory. Although the vehicles can only be delivered at the rate of one a week, it is hoped that all the tramcars purchased will be in service in the city in the near future.

New Glasgow Tobacco Factory.—The tobacco firm, W. D. and H. O. Wills, Ltd., are to begin moving shortly from their present premises at Tobago-street, Glasgow, to a new factory at Alexandria-parade, in the same city. The offices at the factory were opened on October 5, and the firm's manufacture of cigarettes in Scotland will be transferred gradually to the new building during the next few months. The factory has been designed with a view to obtaining maximum efficiency and production and the best possible working conditions.

Rapid Construction of Glasgow Houses.—The building of a group of 1,800 houses at Drumchapel for Glasgow Corporation, which began last May, has progressed so well that some of them are expected to be ready for occupation before the end of the year. They are being constructed on the "cross-wall" system. Mr. John Lawrence, chairman of the group of five contractors who are sharing the work, claimed recently that these firms had undertaken to complete all the houses in 1 year and 11 months, but his own opinion was that the work would be finished in 18 months, that is, in only 468 working days. He suggested that this achievement was four times better than had been accomplished by the biggest firms of building contractors in England, and that it must be a world record.

CLEVELAND AND THE NORTHERN COUNTIES.

Objections to New Timing System.—Men employed at the North Shields works of Armstrong Whitworth & Co. (Pneumatic Tools), Ltd., have objected to a proposal to introduce an American system of "clocking in." The company desired that every employee should be required to "clock in" and "clock off" for each individual job, which they state is the recognised system in the United States. By this means, it would be possible to find out how long was taken on each job, and the method was expected to lead to greater efficiency. The employees, however, consider such a procedure to be tedious and unnecessary. Owing to these difficulties, the firm recently issued notices terminating their employment to 100 of its employees, but these have been withdrawn to enable negotiations with the Amalgamated Engineering Union to proceed.

Increased Employment in the Tees-Side Area.—Substantial reductions in the number of unemployed persons on Tees-Side and in the Cleveland district were recorded during the middle of September last. The number of men then out of work was 1,791, against 2,123 in mid-September, 1952, a decrease of 332. Women unemployed numbered 2,202, compared with 2,458 in mid-September last year; and young people 439, compared with 607 last year.

Record Coal Production in the Mid-East Durham Area.—Miners employed at Vane Tempest Colliery, Seaham, County Durham, have recently achieved an output of 14,932 tons of coal in one week. This is the highest production total for any week since the colliery commenced operations in 1929.

Closure of Coal Seam.—The North-West Durham Area of the National Coal Board have decided to close the Three Quarter Seam at Chopwell Colliery, Rowlands Gill, County Durham, thereby involving the displacement of about 100 miners. At least 60 of these men will be absorbed at local drift mines, but the remainder are likely to become redundant, at any rate for the time being.

Proprietorship of Berwick Shipyard.—A new company has been formed, with the title Berwick Shipyard, Ltd., to take over and operate the Berwick shipyard of William Weatherhead and Sons, Ltd. The company has a capital of 5,000*l.* in one pound shares, and has orders in hand for nine vessels. It is understood that no changes are contemplated in the type of vessel constructed at the yard and that the present staff will remain.

LANCASHIRE AND SOUTH YORKSHIRE.

Doncaster Power Station.—The first of four 30-MW turbo-alternators has been brought into operation at the new power station at Doncaster, but the other three have still to be installed. One more generator will come into use next year and the remaining two are expected to be working before the end of 1955. In due course, the 66,000-volt overhead cable from Rotherham, which now supplies Doncaster's electricity requirements, will be replaced by a direct cable from the new station, but the bulk of its output will go into the national grid system, via the recently opened sub-station at West Melton.

Objection to Rotherham Development Plan.—The twenty-year development plan of the Rotherham Corporation, which is expected to cost some 17,250,000*l.* is disliked by many industrial firms, including the Rotherham Forge & Rolling Mills Co., Ltd., who state that the proposed inner by-pass road is designed to pass right through their works. The firm's rolling mills are only slightly under the minimum size for nationalisation and the development plan would involve their total destruction. Rotherham Corporation have stated in answer to the firm's objection that there is no intention of proceeding with that part of the plan affecting the works until some time after 1971.

Omnibus with Large Passenger-Carrying Capacity.—A new type of omnibus, with under-floor engine, one deck only, and capable of carrying 61 passengers is being tried out experimentally in Sheffield. The 'bus is 30 ft. long and 8 ft. wide, and permission is to be sought for its operation on middle-distance routes now being served by double-deck 'buses. The city's Traffic Commissioners are being asked to allow 30 standing passengers to be carried. The vehicle is considered by its originators to provide an answer to the queue problem, but drivers and conductors are reported not to be in favour of its adoption.

Modern Steel-Melting Practice.—The majority of steel-melting furnaces recently brought into production in Sheffield have been of the electric-arc type and the tendency has been to install furnaces of much greater capacity than formerly. Mr. W. B. Wallis, President of the Pittsburgh Lectromelt Furnace Corporation, gave an address to some 350 steelmakers and plant suppliers in Sheffield on American electric-arc furnace practice, on September 30, in which he approved the use by British steel manufacturers of the larger types of electric-arc furnaces, and instanced the use in the United States of a number of 125-ton furnaces. He pointed out that still bigger units were under construction. The 60-ton furnace to be installed at the Stocksbridge works of Samuel Fox & Co., Ltd., he affirmed, would be the largest of its kind in the British Isles. He considered that there were many signs that the electric furnace had started to supersede open-hearth furnaces.

THE MIDLANDS.

Suburban Transport Plan.—The Council of the Birmingham Chamber of Commerce have accepted a report prepared by their transport committee on the commission which was set up last year to study the problem of suburban transport in the Birmingham area. The report urges that fuller use should be made of the existing railways in the area, by the provision of extra steam and Diesel train services, the re-opening of closed stations and halts, and the provision of new stations in districts which have become built-up in recent years. It also suggests that certain lines which are at present closed to passenger traffic should be re-opened. Attention is also drawn to the recent experimental use of a three-car lightweight Diesel train on suburban routes centred on Birmingham. On the Birmingham-Solihull route, this train made the journey in 20 minutes, which, it is pointed out, is far quicker than could be done by 'bus or private car under present conditions of traffic congestion. Copies of the report are being sent to the West Midlands Area Transport Users' Consultative Committee.

Work Study in Industry.—Following the recent summer course on work study, held at the new Birmingham University Institute for Engineering Production, Norfolk-road, Edgbaston, Birmingham, 15, a series of short residential courses has been arranged for the coming winter. The courses, which are intended for works managers and senior executives, will begin in November, and will run for two weeks each. The arrangements are under the direction of Professor T. U. Matthew, head of the Department of Engineering Production at the University.

The Talyllyn Railway.—The Talyllyn Railway Preservation Society, a non-profit-making organisation, which is largely composed of light-railway enthusiasts from Birmingham and the Midlands, held its annual general meeting on September 26. The chairman, Mr. W. G. Trinder, reported that the railway carried 27,324 passengers this year, and that traffic receipts had increased from 1,065*l.* last year to 1,300*l.* for the present season.

The Future of a Canal Reservoir.—Cannock Rural District Council are seeking to acquire from the Docks and Inland Waterways Executive the old canal reservoir at Walk Mill, Bridgtown, Cannock, Staffordshire. This reservoir is no longer used commercially, and the Council desire to use the site as a refuse tip. The proposal is being opposed locally on the ground that it will interfere with the amenities of the district.

SOUTH-WEST ENGLAND AND SOUTH WALES.

Traffic at South Wales Ports.—During the eight months ended September 6, 1953, South Wales ports between them handled a total of 14,647,405 tons of materials, which was a decline of more than 850,000 tons when compared with the corresponding period last year. Imports increased from 6,836,746 to 6,906,395 tons, but there was a decline of exports from 8,661,678 to 7,741,010 tons.

Efforts to Improve Welsh Industrial Productivity.—A new productivity committee, to serve the needs of industry in West Wales, was recently inaugurated at a meeting in Swansea of employers, trade-union officials, and representatives of technical institutions and other organisations. Similar committees have already been set up for North Wales and East Wales. Captain H. Leighton Davies, director and assistant managing director of the Steel Company of Wales, Ltd., was appointed chairman of the new committee, and Mr. James Havard, an official of the National Union of General and Municipal Workers, was elected vice-chairman.

Improvement in Tin-Plate Industry.—Nine tinplate mills in West Wales are to be re-opened by the Steel Company of Wales, Ltd. Provided a sufficient labour force is available, four mills at Pontardawe Tinplate Works and five at Gorseinon Tinplate Works will start again on November 2. Both works were put on a care and maintenance basis last May, owing to the lack of demand for tin-plates at that time. In a recent official statement, the company announced that, in view of the steadily increasing demand for tin-plates, they felt justified in restarting some of the mills and were confident that they would be able to maintain them in operation until the new strip mill at Velindre was ready. It may also be possible to bring further mills back into operation in the near future.

Large Contract for Rolling-Mill Equipment.—Richard Thomas and Baldwins, Ltd., and the Steel Company of Wales, Ltd., have placed joint contracts for rolling-mill equipment, worth in all some 4,000,000*l.*, with Davy and United Engineering Co., Ltd., Park Iron Works, Sheffield, 4. This equipment is required for a new large-scale modernisation project in connection with the Welsh sheet and tin-plate industry, and the order is regarded as one of the largest for heavy rolling-mill plant and auxiliaries to be placed with a British manufacturer at one time. The principal items included in the order are a five-stand tandem cold strip mill and a two-stand temper mill for the Ebbw Vale Works of Thomas and Baldwins. Large-scale modifications are to be made to other mills and auxiliaries at Ebbw Vale, with a view to increasing the total capacity of the works for cold rolled tin-plate by from 2,000 to 2,500 tons a week. In addition, a five-stand tandem cold strip mill and two two-stand temper mills are to be built for the new works which the Steel Company of Wales is now completing at Velindre, near Swansea.

NOTICES OF MEETINGS.

IT is requested that particulars for insertion in this column shall reach the Editor not later than Monday morning in the week preceding the date of the meeting.

INSTITUTION OF ELECTRICAL ENGINEERS.—*Western Centre:* Monday, October 12, 6 p.m., South Wales Institute of Engineers, Park-place, Cardiff. Chairman's Address, by Mr. J. Vaughan Harries. *North-Eastern Centre:* Monday, October 12, 6.15 p.m., Neville Hall, Westgate-road, Newcastle-upon-Tyne. Chairman's Address, by Mr. H. Esther. *District Meeting:* Monday, October 12, 7.30 p.m., Royal Hotel, Norwich. "Design Features of Certain British Power Stations," by Mr. S. D. Whetman and Mr. A. E. Powell. *Education Discussion Circle:* Tuesday, October 13, 6 p.m., Savoy-place, Victoria-embankment, W.C.2. Discussion on "How Should the Action of Polyphase Commutator Motors be Approached?" opened by Mr. I. L. Stefani. *North Midland Centre:* Tuesday, October 13, 6.30 p.m., 1, Whitehall-road, Leeds. Discussion on "Technical College Examinations," opened by Mr. R. A. H. Sutcliffe. Thursday, October 15, 7.15 p.m., Offices of the Yorkshire Electricity Board, Ferensway, Hull. Chairman's Address, by Mr. G. Caton. *South Midland Centre:* Tuesday, October 13, 7.15 p.m., Winter Gardens Restaurant, Malvern. "Development of Electrical Aids in Anti-Aircraft Gunnery," by Mr. D. H. A. Huddart. *Radio Section:* Wednesday, October 14, 5.30 p.m., Savoy-place, Victoria-embankment, W.C.2. Chairman's Address, by Mr. J. A. Smale. *Southern Centre:* Wednesday, October 14, 6.30 p.m., Offices of the South Eastern Electricity Board, Hove. "The Testing and Specification of Bushings in Relation to Service Conditions," by Mr. H. Barker and Mr. H. Davies.

INSTITUTE OF PACKAGING.—*Northern Area:* Monday, October 12, 6.30 p.m., Old Nag's Head Hotel, Manchester. "Use of Timber in Packaging," by Mr. A. Bowker.

INSTITUTE OF TRANSPORT.—*Sussex Group:* Monday, October 12, 6.30 p.m., Royal Pavilion, Brighton. "Trends and Influences in Transport Charges," by Mr. J. R. Pike. *Yorkshire Section:* Tuesday, October 13, 6.30 p.m., Great Northern Hotel, Leeds. "The British Army Transportation Service," by Lieut.-Col. A. F. Fielding. *Southern Section:* Wednesday, October 14, 5.45 p.m., Harbour Board Offices, Southampton. "Looking Ahead in Transport," by Mr. W. D. Reakes. *East Midlands Section:* Thursday, October 15, 1 p.m., Mechanics' Institute, Nottingham. "The Production of a National Newspaper," by J. M. Scott. *South-Western Section:* Thursday, October 15, 7 p.m., City Transport Offices, Plymouth. "Transport Users' Consultative Committees," by Mr. M. A. Cameron.

ASSOCIATION OF SUPERVISING ELECTRICAL ENGINEERS.—*Central London Branch:* Monday, October 12, 7 p.m., St. Ermin's Hotel, Caxton-street, S.W.1. Discussion on "Electrical Aspects in Water Engines." *North-West London Branch:* Tuesday, October 13, 8.15 p.m., Rest Hotel, Kenton-lane, Kenton. "Jet Engines," by Mr. A. C. Parkes. *York Branch:* Wednesday, October 14, 7.30 p.m., City Hotel, Lendal, York. Discussion on "The Diesel Generator."

INSTITUTION OF PRODUCTION ENGINEERS.—*Yorkshire Section:* Monday, October 12, 7 p.m., Hotel Metropole, Leeds. "Economics in Production Engineering," by Dr. F. A. Wells. *Preston Section:* Wednesday, October 14, 7.15 p.m., Crown Hotel, Blackburn. "Argon Arc-Welding Processes," by Mr. O. Cobb. *Edinburgh Section:* Wednesday, October 14, 7.30 p.m., North British Station Hotel, Edinburgh. "Some Aspects of Paper Manufacture," by Mr. W. Speirs. *South Wales Section:* Thursday, October 15, 6.45 p.m., South Wales Institute of Engineers, Park-place, Cardiff. "Pattern for Progress," by Mr. A. S. Hoxley. *London Section:* Thursday, October 15, 7 p.m., Offices of Creed & Co., Ltd., Telegraph House, Colston-road, East Croydon. "Production of Cylinder Castings," by Mr. A. Emmerson. *Southern Section:* Thursday, October 15, 7.15 p.m., Polygon Hotel, Southampton. "Production Engineering Research and Metal Cutting," by Mr. R. J. B. Wolfe. *Glasgow Section:* Thursday, October 15, 7.30 p.m., 39, Elmbank-crescent, Glasgow, C.2. "High-Frequency Heating and Induction Hardening," by Dr. R. H. Barfield. *Eastern Counties Section:* Friday, October 16, 7.30 p.m., Britannia Works, Colchester. "A Visit to the United States with a Productivity Team," by Mr. W. F. Garnham.

INCORPORATED PLANT ENGINEERS.—*Dundee Branch:* Monday, October 12, 7.30 p.m., Mathers Hotel, Dundee. Discussion on "Factory Instrumentation." *Manchester Branch:* Tuesday, October 13, 7.15 p.m., Engineers' Club, Manchester. "The Plant Maintenance Team's Visit to the United States," by Mr. C. Troup. *East Midlands Branch:* Wednesday, October 14, 7 p.m., Offices of the East Midlands Gas Board, Parliament-street, Nottingham. Discussion on "The Works Engineer and the Factories Act." *Blackburn Branch:* Thursday, October 15, 7.30 p.m., Grosvenor Hotel, Blackburn. "Gunite in Industrial Building Maintenance," by Mr. G. N. Ternan.

INSTITUTION OF CIVIL ENGINEERS.—*Airport Engineering Division:* Tuesday, October 13, 5.30 p.m., Great George-street, S.W.1. "The Effect of Jet Aircraft on Airfield Pavements, and Associated Problems," by Mr. D. H. Carrack and Mr. D. G. Robertson.

INSTITUTION OF THE RUBBER INDUSTRY.—*London Section:* Tuesday, October 13, 5.30 p.m., 26, Portland-place, W.1. (i) "Rubber Components in the Automobile Industry," by Mr. F. C. Watkins; and (ii) "The Manufacture of Adhesive Tapes," by Mr. J. Dow.

INSTITUTE OF MARINE ENGINEERS.—Tuesday, October 13, 5.30 p.m., 85, Minories, E.C.3. "Operation of a Gas Turbine Under Sea Conditions," by Mr. J. Lamb and Mr. R. M. Duggan.

ILLUMINATING ENGINEERING SOCIETY.—Tuesday, October 13, 6 p.m., Royal Institution, Albemarle-street, W.1. Presidential Address, by Mr. W. R. Stevens.

INSTITUTION OF MECHANICAL ENGINEERS.—*South Wales Branch:* Tuesday, October 13, 6 p.m., South Wales Institute of Engineers, Park-place, Cardiff. Chairman's Address on "The Design of Services for a Large Process Factory," by Mr. C. L. Hilton. *Midland Branch:* Thursday, October 15, 6 p.m., James Watt Memorial Institute, Birmingham. "The Jaguar Engine," by Mr. W. M. Haynes. *Institution:* Friday, October 16, 5.30 p.m., Storey's-gate, St. James's Park, S.W.1. Presidential Address on "The Craftsman," by Mr. Alfred Roebuck.

INSTITUTION OF STRUCTURAL ENGINEERS.—*Northern Counties Branch:* Tuesday, October 13, 6.30 p.m., Scientific and Technical Institution, Corporation-road, Middlesbrough. Chairman's Address on "History of Reinforced Concrete," by Mr. T. Bryce. *Yorkshire Branch:* Wednesday, October 14, 6.30 p.m., Great Northern Hotel, Leeds. Chairman's Address, by Mr. John Dossor.

INSTITUTION OF WORKS MANAGERS.—*Birmingham Branch:* Tuesday, October 13, 7 p.m., Grand Hotel, Birmingham. "Training for Management: The Line of Succession," by Mr. C. D. Law.

INSTITUTE OF BRITISH FOUNDRYMEN.—*Slough Section:* Tuesday, October 13, 7.30 p.m., Offices of High Duty Alloys, Ltd., Slough. "Shell Moulding," by Mr. J. Fallows. *West Riding of Yorkshire Branch:* Wednesday, October 14, 7.30 p.m., Technical College, Bradford. Brains Trust Meeting.

ROYAL SANITARY INSTITUTE.—Wednesday, October 14, 2.30 p.m., 90, Buckingham Palace-road, S.W.1. "The Siting, Construction and Management of Abattoirs," by Mr. A. W. Anderson.

NEWCOMEN SOCIETY.—Wednesday, October 14, 5.30 p.m., Science Museum, South Kensington, S.W.7. (i) "Report on Railways in England in 1826-27 by Carl von Oeynhausen and Heinrich von Dechen," translated and reviewed by Mr. E. A. Forward; and (ii) "First Watt-Type Engine in Denmark," by Mr. H. H. Mansa.

INSTITUTE OF PETROLEUM.—Wednesday, October 14, 5.30 p.m., 26, Portland-place, W.1. Redwood Lecture on "The Friction of Solids," by Dr. F. P. Bowden, F.R.S.

BRITISH INSTITUTION OF RADIO ENGINEERS.—*North-Eastern Section:* Wednesday, October 14, 6 p.m., Institution of Mining and Mechanical Engineers, Newcastle-upon-Tyne. "The Impact of Communication Theory on Television," by Dr. D. A. Bell.

INSTITUTE OF ROAD TRANSPORT ENGINEERS.—*East Midlands Centre:* Wednesday, October 14, 7.30 p.m., Mechanics' Institute, Nottingham. "Hydraulic Servo Systems for Heavy Commercial Vehicles," by Mr. J. St. H. Webb. *Yorkshire Centre:* Thursday, October 15, 7.30 p.m., Hotel Metropole, Leeds. "The Maintenance of High-Speed Diesel Engines," by Mr. H. L. Parrish.

DIESEL ENGINE USERS ASSOCIATION.—Thursday, October 15, 2.30 p.m., Caxton Hall, Victoria-street, S.W.1. "Dual-Fuel Engines," by Mr. G. A. Keep and Mr. K. M. Cummins.

INSTITUTION OF MINING AND METALLURGY.—Thursday, October 15, 5 p.m., Geological Society's Apartments, Burlington House, Piccadilly, W.1. (i) "The Technique of Mine Valuation in Some Special Cases," by Mr. Jack Spalding; and (ii) "Underground Water Encountered at Blyvooruitzicht Gold Mine," by Mr. R. C. Curtin.

CHADWICK LECTURE.—Thursday, October 15, 5.30 p.m., Royal Society of Arts, John Adam-street, W.C.2. "Air Pollution," by Mr. C. J. Regan.

CHEMICAL SOCIETY.—Thursday, October 15, 7.30 p.m., Royal Institution, Albemarle-street, W.1. "The Mechanism of Reactions Between Gases and Solids," by Dr. J. S. Anderson, F.R.S.

MANCHESTER ASSOCIATION OF ENGINEERS.—Friday, October 16, 6.45 p.m., Engineers' Club, Manchester. "The Formation and Prevention of Atmospheric Contamination in Factories," by Mr. W. A. Attwood and Mr. W. B. Lawrie.

PERSONAL.

The Minister of Civil Aviation has announced that the existing appointments of SIR MILES THOMAS, D.F.C., as chairman of the British Overseas Airways Corporation, and of LORD DOUGLAS OF KIRTLESIDE, G.C.B., M.C., D.F.C., as chairman of British European Airways, both of which were due to terminate next year, are being extended. SIR ARNOLD OVERTON, K.C.B., K.C.M.G., M.C., is being appointed to the board of B.E.A., with special responsibilities for finance and organisation. MR. BASIL SMALLPEICE, financial comptroller of B.O.A.C., is being appointed to the board of B.O.A.C.

MR. H. E. JACKSON, MR. G. A. WOODRUFF and MR. C. W. CUMBER have relinquished their appointments on the Council of the Aluminium Development Association, 33, Grosvenor-street, London, W.1, and DR. MAURICE COOK and MR. J. F. PAIGE have been appointed to the Council. DR. N. P. INGLIS succeeds Dr. Maurice Cook on the executive committee of the Association. MR. F. G. WOOLLARD and MR. F. R. C. SMITH have resigned from the committee and their places have been taken by MR. HAROLD GOODWIN and MR. J. H. MAYES.

THE BRITISH WELDING RESEARCH ASSOCIATION, 29, Park-crescent, London, W.1, announce that DR. A. A. WELLS has been appointed chief research engineer and head of the Engineering Research Station at Abington, near Cambridge. MR. R. P. NEWMAN will become chief administrative officer of the Station.

MR. W. V. BINSTEAD, A.M.Inst.W., who had been with the Northern Aluminium Co., Ltd. for 16 years, including 12 years as welding and joining engineer in the company's sales development division at Banbury, has taken up a similar appointment with the Saturn Oxygen group of companies, Downshire House, Roehampton-lane, London, S.W.15.

MR. IAN MCLEOD, Mem.A.S.M.E., A.M.I.Prod.E., has joined the process engineering division of Sharples Centrifuges Ltd., Tower House, Woodchester, Stroud, Gloucestershire, and will undertake investigations into applications of the firm's centrifugal equipment.

MR. J. A. TAYLOR, A.M.I.C.E., A.M.I.E.E., retired from his position with Pritchett & Gold and E.P.S. Co., Ltd., Dagenham Dock, Essex, at the end of last month.

MR. GEORGE PULLEN, formerly with Leyland Motors, Ltd., has been appointed works supervisor to Transport Engineering and Equipment, Ltd., Willow-lane, Lancaster.

MR. F. J. GROVES, 2, Arnewood-road, Southbourne, Bournemouth, has been appointed representative of Sanderson Brothers and Newbould, Ltd., Newhall-road, Sheffield, for Hampshire and Dorset.

MR. DERMOT W. KENT, B.A., A.C.A., has resigned from the board of the Igranic Electric Co., Ltd., Bedford, in order to become commercial director of their associated firm, Sentinel (Shrewsbury), Ltd., Shrewsbury, Shropshire.

AIR-COMMODORE JAMES WARBURTON has been appointed a director of Auto Diesels, Ltd., Uxbridge, Middlesex, and will be mainly concerned with the company's aircraft equipment division.

MR. W. L. HEYWOOD, O.B.E., has been appointed a member of the Advisory Council for Scientific and Industrial Research, with effect from October 1. He is secretary of the National Association of Unions in Textile Trades and general secretary of the National Union of Dyers, Bleachers and Textile Workers. MR. E. FLETCHER has retired from the Council on the completion of his term of office.

MR. G. BURDON, B.Sc., senior engineer and ship surveyor in the Marine Survey Service of the Ministry of Transport, has been appointed principal officer of the West Coast of Scotland survey district, Glasgow, in succession to MR. C. E. DANIELS, O.B.E., who has retired.

MR. W. A. CREWE, general manager of the Delco-Remy-Hyatt Division of General Motors Ltd., 111, Grosvenor-road, Westminster, London, S.W.1, is due to retire next year, after more than 30 years' service with the organisation. In consequence of this impending retirement, MR. C. H. CHARLES, general sales manager, has been appointed executive assistant to the general manager; MR. W. B. JONES, power and industrial sales manager, has been promoted to be general sales manager; and MR. S. JACKSON, parts and accessories sales manager, has been made assistant general sales manager. MR. L. BELL has been appointed supply manager in succession to MR. G. E. ELEN, who has been transferred to the firm's Frigidaire Division.

MR. J. JERMAN, managing director of Hughes Bolckow Shipbreaking Co., Ltd., Blyth, has retired after more than 30 years service. He joined the firm in 1922, became secretary in 1926, was appointed a director in 1936, and became managing director six years later. MR. ERIC NORMAN has been appointed secretary, and MR. J. BRUCE, works manager, has been elected to the board.

A TRANSFORMER FACTORY.

(*For Description, see Page* 471.)

FIG. 1. SMALL-TRANSFORMER ASSEMBLY.

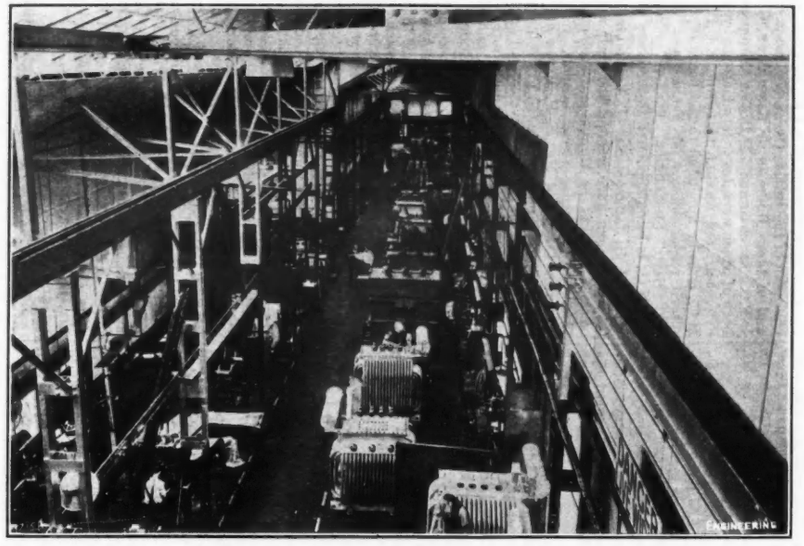


FIG. 2. LARGE-TRANSFORMER ASSEMBLY.

FIG. 3. WINDING SHOP.

FIG. 4. MAIN RESEARCH LABORATORY.

ENGINEERING

35 & 36, BEDFORD STREET, STRAND, LONDON, W.C.2.

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Telegraphic Address:

ENGINEERING, LESQUARE, LONDON.

Telephone Numbers:

TEMPLE BAR 3663 and 3664.

All editorial correspondence should be addressed to the Editor and all other correspondence to the Manager.

Accounts are payable to ENGINEERING Ltd. Cheques should be crossed "The National Provincial Bank, Limited, Charing Cross Branch." Post Office Orders should be made payable at Bedford Street, Strand, W.C.2.

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ENGINEERING may be ordered from any newsagent in town or country and from railway bookstalls, or it can be supplied by the Publisher, post free, at the following rates, for twelve months, payable in advance:—

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Terms for displayed advertisements can be obtained on application to the Manager. The pages are 12 in. deep and 9 in. wide, divisible into four columns 2¼ in. wide. Serial advertisements will be inserted with all practicable regularity, but absolute regularity cannot be guaranteed.

The charge for advertisements classified under the headings of "Appointments Open," "Situations Wanted," "Tenders," etc., is 10*s.* for the first four lines or under, and 2*s.* 6*d.* per line up to one inch. The line averages six words and when an advertisement measures an inch or more, the charge is 30*s.* per inch. If use is made of a box number the extra charge is 1*s.* per insertion, with the exception of advertisements appearing under "Situations Wanted." Series discounts for all classified advertisements can be obtained at the following rates:—5 per cent. for six; 12½ per cent. for thirteen; 25 per cent. for twenty-six; and 33⅓ per cent. for fifty-two insertions.

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Classified advertisements intended for insertion in the current week's issue must be received not later than first post Monday.

"Copy" instructions and alterations to standing advertisements for display announcements must be received 16 days previous to the date of publication, otherwise it may be impossible to submit proofs for approval.

The Proprietors will not hold themselves responsible for advertisers' blocks left in their possession for more than two years.

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ENGINEERING

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LIFEBOATS OR RAFTS?

THERE are few things more likely to provoke controversy than a suggestion that a change should be made in some long-established practice. Sir William Wallace, in his presidential address to the Institution of Engineers and Shipbuilders in Scotland last Tuesday, which we report on page 458 of this issue, proposed such a change. He dealt with matters of life and death at sea and his bold words command the attention of those who value tradition and equally of those who welcome innovation. He established a strong case for the provision of inflatable rafts in place of lifeboats as life-saving equipment in ships. A set of inflatable rafts, sufficient to carry the whole of the passengers and crew of the ship, would not only weigh much less than the corresponding lifeboats, but would also, he contended, provide reasonable comfort for survivors waiting to be picked up by other ships. In some cases, the rafts would even ensure survival in conditions that could only lead to death, due to exposure, in lifeboats.

When the Titanic struck an iceberg in the Atlantic in 1912, the 16 lifeboats, with a total capacity of 736, saved 705 lives, but the ship's complement was 2,208. That disaster lead to the requirement that certain passenger ships should carry lifeboats capable of holding all persons on board. Though this requirement cannot be applied, for example, to a cross-channel ship, it necessitates the provision of equipment which is placed high up in the ship, and, in conjunction with other safety regulations, it has presented naval architects with a problem of design which can only be solved by making the ship less seaworthy. It is no answer to this objection to say that aluminium alloy can be used for funnels, deck-houses and other superstructures, since by using inflatable rafts and retaining those aluminium-alloy structures the stability of a ship could be increased still further. A large Atlantic liner carrying 3,200 persons has to provide lifeboats and associated equipment weighing about 450 tons—more than twice the weight of the passengers and crew. Sir William, quoting from the official report on the tragic loss of the Princess Victoria, concluded that after the order was given to abandon ship not a single lifeboat could be launched by the designed methods, and it was not possible to launch boats from any of the rescuing ships. "What can we do," he said, "to provide safety for all on board and yet eliminate this very great weight placed in the worst possible position on the ship?" He visualises a modern liner equipped with, say, two efficient power-driven lifeboats with every modern device for safety at sea, and two emergency lifeboats for use in case of "man overboard" or other similar incident, but with provision made for the safety of the remainder of the passengers and crew in inflatable equipment of the type similar to that approved for the rescue of aircraft passengers and crew.

At sea there is usually more time to take action and organise emergency arrangements than in the air. Modern rafts supply a surprisingly high standard of comfort. During a test in Arctic conditions with the sea at 35 deg. F., a covered inflatable raft was manned and within an hour the temperature inside it had risen to such an extent that increased ventilation was required. In tropical conditions a double canopy ensures shade, and open entrances allow a draught of cooling air whenever there is a slight breeze. Present-day rafts are automatically inflated as soon as they alight on the water. Sir William suggests that the rafts could be stowed away on the most convenient deck, possibly the promenade deck. On the deck head he would install light girders carrying a sliding member from which would be suspended, when required for launching the raft, a light frame with a rigid base capable of supporting the inflated raft with all personnel on board. The frame would be suspended just clear of the deck, and when all were on board it would be swung out by one man and lowered by means of a small hand winch, the only function of which would be to lower the raft on the brake and recover the frame ready to launch the next raft. The frame would be provided with a quick release, thus allowing the raft to float clear of the frame and the ship. If time were short, the rafts could be thrown overboard and embarked from the sea. For this purpose launching equipment on the scale of, say, one for each three rafts carried would be provided. The estimated weight for all this equipment on an Atlantic liner carrying 3,200 persons is 69 tons, including the two emergency lifeboats weighing 30 tons together. This 69 tons, which compares with the 450 tons for lifeboats, would be distributed more conveniently: 30 tons on the boat deck and 39 tons in various positions lower down in the ship. Maintenance also would probably be less of a problem with inflatable rafts than with lifeboats.

Sir William also hit hard at existing regulations for compelling shipowners to provide lifebelts for the maximum number of persons to be carried on the ship, since it is specified that these lifebelts should not be of the inflatable type using air as the buoyancy medium. As with rafts, improvements in design and construction have brought lifebelts to the stage where they are in every way more efficient than the older type, and, as he remarked, the inflatable lifebelts are permitted for use in aircraft. Sir William's presidential address is a challenge to everyone concerned with the design and use of ships. His proposals, if they had been put forward by a younger man, might have been dismissed as the ill-considered ideas of one who had no conception of the complexity and gravity of the subject, but they have been put forward by one with long experience. Though they may be regarded as revolutionary in a service which inevitably respects tradition and long usage, they should be given wide publicity and consideration. Every point of view should be expressed. No comment, however small or detailed, is irrelevant to the discussion. In all industries equipment for

safeguarding the lives of peoples is only developed and perfected over many years of use. Sudden and fundamental changes are regarded with suspicion. Sir William's proposed change would seem to be one of the few that will eventually be justified.

NATIONAL ELECTRICITY SUPPLY.

Financial results provide a universal and fairly accurate yardstick for measuring the operation of both publicly and privately owned trading undertakings. In commenting on the fifth annual report* of the British Electricity Authority for the year ended March 31, 1953, which was published last week, we may therefore deal initially with this side of that body's activities before proceeding to matters of more technical importance. At the end of the year under review the overall surplus of the Central Authority was just over 7¼*l.* million, compared with about 5¼*l.* million at the conclusion of the previous 12 months. This result, if satisfactory compared with those of other nationalised bodies, does not, however, represent a return of more than 2½ per cent. on a turnover of 292*l.* million and cannot therefore be said to be excessive. If, on the other hand, it is considered to be the duty of nationalised bodies to achieve a minimum balance on the right side rather than to make large profits those concerned are to be congratulated on their endeavours. It is, perhaps, only right to add that the improvement we have noted was due, as far as the Central Authority was concerned, to an increase of 3*s.* per kilowatt in the maximum-demand charge for the electricity supplied in bulk to the Area Boards; and, in the case of the Area Boards, mainly to increases in retail prices, which have been made within the past two years, the earlier of which only became fully effective during the year under review. It would have been interesting to have had some estimate of the trading results had these changes not been made, especially as under existing conditions, unfortunately, further increases cannot be excluded from the picture.

Turning to technical matters, the report contains a full account of the position in the fields of both generation and transmission, including plant programmes, research and operation. The engineering reader may, in fact, find the treatment of those matters rather diffuse and may wish for a more succinct description of the progress that has been made; and especially of the difficulties that have been encountered and overcome. It must be remembered, however, that this document is intended for lay readers, as well as for engineers, and that the attitude of some of the former is not characterised by any great friendliness to electricity supply. It may therefore be justifiable to dot "i's" and cross "t's" in the hope that in time a more judicial attitude may be engendered.

As regards generation, at the date of the report the Authority owned 285 power stations with a total installed capacity of some 17,157 MW and a total output capacity, assuming all plant to be in service, of 15,535 MW. During the year an additional output capacity of 1,423 MW was brought into service, giving a net increase of 1,321 MW when the removal of some unserviceable plant and the revision of the ratings of some other plant are taken into account. Seven new power stations, with an aggregate output capacity of 476 MW, were brought into partial operation during the year, the largest being that at Keadby, near Scunthorpe, with an output capacity of 112 MW. In recording these figures, the report points out that while the increase in generating capacity during the year exceeded that in the demand for electricity, the shortage of plant was still substantial. In fact, had the weather during the 1952-53 winter been extremely cold there would have been a deficiency of some 2,400 MW and extensive load-shedding would probably have been necessary. To the engineer, therefore, it would seem clear that some acceleration in the rate at which new plant is installed is essential, in order that the situation in this respect may be improved; there are some, however, who hold that the Authority's present policy betokens both extravagance and an incorrect estimate of the country's future demands for electricity. Only the future can, of course, disclose whether they are right.

There are, however, as is well known, two practical obstacles to any great change for the better: one is the manufacturing capacity of the country, although the effort of this should not be over-emphasised; and the other, and more important, is the Government policy, which has led to the decision that export orders for power-station plant must have priority over orders by the Authority, in respect of the latter's programmes for part of 1956 and for 1957-59. Without going into any great detail, it may be pointed out that the result of this method of dealing with what is undoubtedly a difficulty may be that in 1956 the permitted increase in plant will only be 1,550 MW, compared with an optimum figure of 1,800 MW and in 1959 1,750 MW, instead of 1,900 MW. Now lip-service and propaganda in favour of the greater use of electricity for all purposes and emphasis on the part that this form of power can play in securing the prosperity of the nation will be worse than useless if sufficient plant is not available to meet the demand. The Authority has therefore done well to make representations to the Government on this point and we are glad to learn that means of facilitating export orders without delaying the delivery of plant for use in this country are being discussed at a fairly high level. We hope that as a result not only will a favourable decision be reached, but that this will be of a long-term character, so that the present situation will not recur.

In spite of present disabilities, at the end of the year under review, 34 new power stations were being built and 52 existing stations were being extended as part of the construction programmes to the end of 1957, the aggregate installed capacity involved being some 9,440 MW. In addition, the 1958 programme, which was adopted during the year, covers six new power stations and extensions to seven stations, which have been started since the war. The bulk of the plant in these programmes will consist of "standard" 30-MW and 60-MW sets with steam conditions, respectively, of 600 lb. per square inch and 850 deg. F., and 900 lb. per square inch and 900 deg. F. At Willington "A," near Derby, 100-MW sets, utilising steam at 1,500 lb. per square inch and 1,050 deg. F., are to be installed, while the plant at Blyth and Drakelow "B," near Burton-on-Trent, will consist of 120-MW sets operating on a re-heat cycle with steam at 1,500 lb. per square inch and 1,000 deg. F. What is unfortunately called unitisation is to be employed at all these stations, the result being that the boilers at both Blyth and Drakelow "B" will be rated at no less than 860,000 lb. of steam per hour. Good progress is therefore being made on the technical side the results of which will be watched with interest.

Even as it is, the part played by the new plant is being reflected in the increasing efficiency of operation. In fact, the overall thermal efficiency of the Authority's steam power stations rose steadily from 20·87 per cent. in 1947–48 to 22·04 per cent. in 1951–52 and reached 22·72 per cent. in 1952-53. In the latter year, too, an average of only 1·384 lb. of coal were consumed per kilowatt-hour sent out, compared with 1·417 lb. in the previous year. The total fuel consumption during 1952–53 was 35¾ million tons, or 1·7 per cent. more than in the previous year, while the quantity of electricity generated increased by 4 per cent., thus providing a further example of the improvements obtained in generating efficiency. These figures should, in fact, provide some answer to those who preach the extravagance of utilising our coal resources to generate electricity. The output in 1952–53 was over 61,600 million kilowatt-hours, or 4 per cent. more than in the previous year, and the peak demand was 13,301 MW, compared with 12,344 MW in the winter of 1951–52. Nearly 14 million consumers were served, and it is noteworthy that these included 134,429 farms.

Good progress was also made on the transmission side. At the end of the year under review 4,682 route miles of the main grid were in use, of which 4,174 miles were being operated at 132 kV and the remainder at 66 kV or lower voltages. Some 200 route miles of 132-kV lines were added during the year and a further 372 route miles of the new 275-kV supergrid were being constructed. The first section of this supergrid, comprising 41 route miles of single-circuit line between Staythorpe and West Melton, was in operation during the year at 132 kV and, as already noted in Engineering, has been working at 275 kV since the beginning of July.

Returning, in conclusion, to the financial position, as disclosed in the report, it must be remembered that the electricity-supply industry was enjoying a fair degree of prosperity when reorganisation took place. It was, therefore, in a happier position than such other nationalised industries as coal and the railways, of which the same could not be said. Since its formation, however, the Authority has been faced with ever-rising capital costs and this trend continued during the year under review, although the rate of rise diminished owing to the fall in the prices of certain raw materials. In addition, operating costs continued to rise. For instance, fuel and transport rates both increased by nearly 6 per cent., adding 5¾*l.* million to the total delivered cost of fuel; and increases in salaries and wages accounted for an increase of 3½*l.* million. The first five years of nationalisation have, in fact, involved a continuous struggle between costs and efficiency, for the results of which the consumer has good reason to thank the technical and administrative staffs of the British Electricity Authority.

* *British Electricity Authority. Fifth Report and Statement of Accounts for the year ended March 31, 1953.* H.M. Stationery Office. [Price 3*s.* 6*d.* net.]

NOTES.

HISTORIC COLLECTION OF ELECTRICAL MACHINES AND APPARATUS.

To mark the 75th anniversary of their parent company, Messrs. Crompton Parkinson, Limited, Crompton House, Aldwych, London, W.C.2, have opened an historic collection of electrical machines, arc lamps, instruments, switches, etc., which, together, tell a very interesting story of the achievements of the firm of Crompton during the first 25 years of its existence. As will be readily understood, the collection is largely a record of an important period in the life of Colonel R. E. B. Crompton, R.E., C.B., F.R.S., who died in 1940 at the age of 94. Although Colonel Crompton is best remembered as an electrical engineer and was twice President of the Institution of Electrical Engineers, he made important contributions to mechanical and civil engineering, and was a member of both the major institutions covering those branches of the profession. He became interested in electric lighting in 1878 and soon afterwards an improved arc lamp of his design was developed and manufactured in the works of Dennis and Company, Chelmsford. One of Crompton's first arc lamps is included in the historic collection. At that time he was using generators of various types which were not sufficiently reliable for his requirements, so, in conjunction with a Swiss engineer, Mr. Emil Burgin, he designed an improved dynamo for which he

obtained the sole manufacturing and selling rights. The production of this dynamo was started at Chelmsford, and the first machine was completed in December, 1880; a machine of this type, which remained in service until 1926, is included in the collection. The introduction of the incandescent lamp led to a rapid expansion in Crompton's business and, in 1881, he formed the firm of R. E. Crompton and Company, at Chelmsford. Steady improvements in dynamo design, for which Crompton himself was mainly responsible, followed. He and his collaborators were also responsible for the design and manufacture of numerous electrical measuring instruments and the collection includes a representative selection of these. Various examples of switches, lampholders, fuses and connectors used in early incandescent-lamp installations also find a place in the collection. In 1888, the firm was formed into a limited liability company and soon afterwards were producing practically everything electrical. Much of the output was for use in tropical countries and the collection includes an early low-speed ceiling fan removed recently from a Singapore club after many years of service. Another interesting item in the collection is a 15-h.p. direct-current crane motor which dates from 1896 and was taken out of service in 1946 although still in good working order. Several other machines exhibited went into service before 1890 and had useful lives of over 40 years. Alternator design of the last decade of the Nineteenth Century is represented by a revolving-armature machine which was in service until 1947. An induction motor made early in the present century, which was still working in 1951, when it was presented to the collection, is another interesting item. By the commencement of this century, however, the pioneering phase of the electrical power industry was over, but Crompton continued to be associated with the firm until 1912. In 1927, the firm was amalgamated with F. and A. Parkinson, Limited, to form the present company, which has since become associated with the British Electric Transformer Company, Limited, and Derby Cables, Limited. Subsequent developments included the construction of a lamp factory at Guiseley and a short-circuit testing station at Chelmsford. The Young Accumulator group of companies were merged with the Crompton Parkinson organisation in 1945 and their interests, soon afterwards, were extended to include stud welding. To-day, Crompton Parkinson, Limited, is one of the largest manufacturing organisations in the British electrical industry and has extensive manufacturing and marketing interests overseas, which are well known to the present generation of electrical engineers. Their early history, of which we have been able to give only a very brief summary, is well epitomised in the historic collection which should have a high educational value to future generations.

INDUSTRY AND TECHNICAL EDUCATION.

In his presidential address to the Manchester Association of Engineers on October 2, Professor H. Wright Baker said he believed there was still much to be done by industry in discovering among its apprentices those who possessed both personality and the ability to profit from higher studies. Though the latter factor might not be of the highest order, these men might become the backbone of industry and, once they had been selected, ways would have to be found to provide the training which best fitted the needs of each man. The more difficult but ultimately more effective solution, and one which should, in general, increase the recruitment of men of higher mental calibre might be based on the schools. The problem was not only that of providing young men having the factual knowledge which was so essential. "They should burn with a fire of their own, and their fuel, and the excitement which will fire it, should come naturally and readily from things and events of their own time." There must be discipline, he said, but a sensitive foot on the accelerator was far better than a brake. The glamour and excitements of the borderline of the possible—supersonic flight was the present craze—had their dangers, but time would adjust the balance, as it always had done. There remained, however, a great need to impart to headmasters and careers masters, and to parents, such facts as that a petroleum refinery was not the concern of chemists alone, that Cornflakes needed more than a reliable cook, that engineering was not restricted either to dirty refuges for dullards or to little back rooms for the eccentrically-brilliant who happened to have been born with a flair for the practical. Professor Baker described how, in order to overcome the gap between those who taught engineering design and those who practised it, they were using at Manchester actual drawings from engineering firms. Some hundreds of such drawings had been selected, graded and put into use. A reality had been found which was so often missing before, and the results achieved were very encouraging. The association between education and industry had proved very stimulating. He referred to the setting up of their metrology laboratory, to which many engineering firms in the district had contributed. It was only prudent, he said, for us to ask for the advice of the National Physical Laboratory in matters of equipment and the training of staff, but no one then planned the subsequent development of a full and free partnership with the N.P.L., in which Manchester accepted the special role of teaching partner. In three years, 95 teachers from colleges and universities had studied and worked in the laboratories, and in two years 34 special students had received other training. A steady stream of problems came in and the facilities were in constant use for research. "Where so much has been done by common action to provide institutions and colleges suitable for an industrial area," he concluded, "there still remains the great task of ensuring that the institutions themselves are adequately filled."

NEW BALL-BEARING FACTORY.

On October 2 the Ransome and Marles Bearing Company, Limited, formally opened their new factory at Annfield Plain, County Durham. The ceremony was performed by Mr. A. R. W. Low, C.B.E., D.S.O., M.P., Parliamentary Secretary to the Ministry of Supply. The site at Annfield Plain was chosen in conjunction with the Ministry of Supply and North East Trading Estates, expansion at the main factory at Newark being limited by the labour supply. At this new factory, which will employ some 750 workpeople, only the races will be made, the balls and rollers coming from Newark as the capacity of this plant is sufficient for both factories. The works layout has been made to give the easiest flow of material possible—raw material entering at one end and the finished product leaving at the other. Precision machine tools of the latest design are being installed, together with modern heat-treatment plant. There are also a large inspection department and a laboratory for materials testing. Heating and ventilation have been carefully worked out and air filtration is used in the finishing department. Full canteen facilities have also been provided for all personnel. The factory, covering nearly 3½ acres, was built by Holland & Hannen and Cubitts, Limited. There is room at the site for further building.

BRITISH EUROPEAN AIRWAYS.

During the year which ended on March 31, 1953, British European Airways traffic increased by 19 per cent., and some 1,400,000 passengers were carried over 373 million passenger miles. British European Airways is thus to-day the largest airline outside the United States. In the annual report of the Corporation for the year 1952-53, published recently by H.M. Stationery Office (price 5*s.* 6*d.*), it is stated that the revenue increased by 21 per cent., and the operating loss was decreased by 7 per cent. to 1,155,644*l.*, although the net loss rose by 2 per cent. to 1,459,131*l.* Since, however, this figure includes the increased tax on fuel paid to the Treasury, when allowance is made for this the net cost of the Corporation to the taxpayer during 1952-53 was reduced by about 60,000*l.* British European Airways have a difficult economic task on account of the highly seasonal nature of their traffic, and the relatively short distances per passenger—the average journey during 1952-53 was 266 statute miles, and the average fare 7 guineas. To alleviate the seasonal problem, first-class services are to be introduced next year which, it is hoped, will attract non-seasonal business traffic and will also increase the revenue rate. The introduction of highly competitive aircraft such as the Elizabethan, which has now overcome its heavy initial "teething troubles," and the Viscount, the first commercial propeller-turbine aircraft, "can bring the Corporation to a profitable state during the next few years." There is no immediate prospect, however, of a reduction in deficit. B.E.A's sponsoring of the Viscount air-liner (which did not enter passenger service until after the end of the financial year) has contributed greatly to the export sales of this aircraft. It is estimated that the cost to B.E.A. of developing the Viscount for commercial use is not less than 1,000,000*l.*, spread over about four years. The efficiency of the Corporation's engineering activities has already gained by the transfer of maintenance work from Northolt to the new base at London Airport, which was completed by the end of 1952. By the end of this year, all the London engineering department, including the project and development panel, will be stationed at London Airport. The Renfrew maintenance base has also undergone further development. At March this year, the B.E.A. fleet included 20 Elizabethans, 40 D.C.3 Dakota variants, plus two Dart-Dakota freighters which are to be taken out of service, 17 Vikings, of which 12 have been sold, and 29 Admirals (Vikings converted for 36 passengers)—the whole Viking and Admiral fleet are expected to be withdrawn from service by October, 1954—nine D.H. 89 Islanders, three Sikorsky S 51 helicopters (to be replaced by three Bristol 171 helicopters), two Bell helicopters and one Bristol 171 helicopter on loan. An interesting light on the present economics of helicopter operation is shown by the fact that a set of rotor blades for one type of helicopter costs 6,000*l.*, and has to be renewed every 150 hours.

SUPPLY SECTION SUMMER MEETING, INSTITUTION OF ELECTRICAL ENGINEERS.

The summer meeting of the Supply Section of the Institution of Electrical Engineers was held in South Wales from Thursday, September 24, to Sunday, September 27. The chairman of the Section (Mr. C. M. Cock) and Mrs. Cock were present and some 150 members and their ladies attended. An informal gathering took place at the Seabank Hotel, Porthcawl, on the first evening, during which a film describing the operation of the Abbey Works of the Steel Company of Wales was shown, while on the following morning visits were paid to the works of the Metal Box Company, Limited, at Neath, to the National Oil Refineries, Limited, at Llandarcy, and to the Neath Abbey Woollen Mills. The Neath factory of the Metal Box Company has a total floor area of 645,000 sq. ft and is designed for the production on a large scale of can components and printed and lacquered sheets. The plant consists of about 140 individual production units, for the operation of which some 1,300 built-in motors are used. A supply is obtained from the grid at 11 kV, the maximum demand being about 1,000 kW. The Llandarcy refinery is designed to process about 3,500,000 tons of crude oil per annum, the plant including a vacuum distillation unit which provides the feed stock for a line of units as a stage in the manufacture of high-grade refined lubricating oils. It also provides feed material for a catalytic-cracking plant from which high-octane motor spirit is made. At the present time a power house with a total capacity of 13 MW is being erected, the turbines in which will exhaust to the process-steam mains at a pressure of 200 lb. per square inch. In the afternoon a visit was paid to the Abbey Works of the Steel Company of Wales, which is designed to have a production of 1,500,000 tons per year. Electric power is largely used in its operation, and a full description of its equipment was given on page 1 of our 173rd volume (1952). In the evening the party were entertained by the South Wales Electricity Board, and on Saturday, September 26, inspections were made of the Ffaldau and Wyndham Collieries of the South Western Division of the National Coal Board. The visit concluded on Sunday with a visit to Brecon.

THE INSTITUTION OF NAVAL ARCHITECTS' AUTUMN MEETING.

(*Continued from page* 426.)

After the presentation by Lord Runciman of the diploma of honorary membership to H.R.H. Prince Bernhard, on the morning of September 15, the members and their ladies proceeded by motor coaches from Scheveningen, where the technical sessions were held, to The Hague to witness the ceremonial return of Her Majesty Queen Juliana from the State Opening of Parliament. In the afternoon, the technical sessions were resumed, with Sir Stanley V. Goodall, K.C.B., in the chair, to hear and discuss the second and third papers in the programme, namely, those of Mr. J. Brown, B.Sc., and Mr. J. M. Ferguson on "Tests of Launching Greases," and of Ir. J. H. Krietemeijer on an "Optical Marking-off System for Plates and Sections in Shipbuilding." A summary of the paper by Mr. Brown and Mr. Ferguson is given below.

Tests of Launching Greases.

The researches described by Mr. Brown and Mr. Ferguson arose out of a questionnaire addressed to British shipbuilders by the British Shipbuilding Research Association on the current practice in launching procedure. This showed that, while Tallene grease, in its various seasonal grades, was in common use, there existed no reliable guide to its frictional characteristics with varying pressures and declivities. The Association recommended, therefore, that a series of systematic tests should be made to ascertain these properties and this was undertaken by Messrs. John Brown and Company, Limited.

The tests were grouped in four series, of which the first comprised six tests, at a declivity of $\frac{1}{8}$ in. per foot, with pressures from $1\frac{1}{2}$ to 3 tons per square foot, and a seventh at a declivity of $\frac{1}{4}$ in. per foot and a pressure of 2 tons a square foot. As these tests were not conclusive, another series (of 18 tests) was undertaken, covering the same range of pressures, but at declivities of $\frac{1}{8}$ in., $\frac{3}{16}$ in., $\frac{1}{4}$ in. and $\frac{3}{8}$ in. per foot. A study of Sir Robin Rowell's work on stresses in launching triggers* suggested a method of measuring these forces, and a third series of tests was arranged, with this as the main objective; this series covered a range of pressures from 1 ton to 3 tons per square foot, and declivities of $\frac{1}{8}$ in., $\frac{1}{4}$ in. and $\frac{3}{8}$ in. per foot. Attention having been directed to the use in America of mineral greases for launching, a fourth series was arranged to investigate a grease supplied for this purpose by the Anglo-American Oil Company, Limited. These tests were made at a declivity of $\frac{1}{4}$ in. per foot and at pressures of 1 ton, 2 tons and 3 tons per square foot. Two special tests were also made at $\frac{1}{8}$ in. per foot declivity and 2 tons per square foot pressure; in the first, Basekote grease was used in conjunction with Tallene oil, and in the second, Tallene grease and Slidekote lubricant.

While the tests, as a whole, indicated that the coefficient of sliding friction might be approximated for various combinations of grease and lubricant, there was difficulty in assessing its value at, and immediately after, the start of motion; and it was considered that the next stage should be to investigate the properties of the greases and lubricants under laboratory conditions. Such tests might also indicate the effects of low temperature, under controlled conditions. The lower static friction values of the American mineral grease might recommend its use, to ensure greater readiness to start; but this feature had to be balanced against the associated increase of load on the triggers—which might have been designed with higher frictional coefficients in mind.

Discussion.

The discussion was opened by Sir Robin Rowell, who said that, in the past, the choice of a good launching tallow and other lubricants was primarily in the hands of the practical shipwright, "who chewed a little of the material and decided whether it was good or bad." Some of the present-day materials, in their raw state, were susceptible to changes in behaviour, principally with pressure, temperature and humidity, and it was only in recent years that any considerable study had been made with those media, and a safer basis of launch preparation established. It was perhaps for that reason that the original questionnaire circulated by the British Shipbuilding Research Association, which was answered for some 78 ships, showed that no major trouble had been experienced due to the behaviour of the launching grease, establishing fairly conclusively that the launching media are fairly reliable. That did not mean that the anxiety of the shipbuilders was any less under conditions which were new to him, and when he had no data to guide him; so that the co-ordination of the experience of shipbuilders was of great value.

The occasion, he thought, was one of the first on which the results of slider experiments had been tabulated so that they could be compared with the results of individual experience. Unfortunately, unlike model resistance experiments, where correlation had been established between model and ship, it seemed that that state had not yet been achieved between the behaviour of a slider and the launching of a ship. In looking for the reasons, it must be realised that it was impracticable to make a slider a scale experiment of a ship; in the case of a ship, both standing and moving ways almost completely covered each other, whereas the slider had only to move a few feet before it was on fresh lubricant. Furthermore, the slider might be regarded as uniformly loaded, the under surface being carefully planed—as, indeed, was the standing way—whereas, in the case of the ship, the loading per square foot throughout the length of the launchway varied considerably, due to the different weight of the ship per foot run of its length, the flexibility of the ship structure and the ability of the ground and the launch make-up to resist the loads imposed upon them. He had calculated that, for an 18,000-ton tanker, if the average grease loading on the ways was 2 tons per square foot, the loading would vary from about 1·5 tons in some areas to 2·5 tons per square foot in others.

A slider was normally turned over upon the launching way, having been previously greased, and weights were applied to it by means of a crane. In the case of the ship, the weight had been let down on to the launching ways over a period of time, with varying degrees of evenness, and with the pressures by no means uniform throughout the sliding surface. He felt that the authors' experiments had been carried out in a reasonably practical fashion and had led to fairly uniform results in their findings, if the initial movements of the slider were disregarded; and from that standpoint a fair amount of valuable information had been gained.

He asked whether any of the speakers who contributed to the discussion could give information on the problem of different sizes of sliders; it was his own belief that, if sliders of different sizes were used, although the inclines and loadings were the same, completely different results would be obtained. Mr. A. Hiley had done some valuable work for shipbuilders in 1913, when he produced his curves of launching declivities, given for varying conditions of load per square foot with varying increases in declivity for a sure start and slide. The lubricants of that day were commercial tallow, soft soap and train oil. Experience had shown that, with present-day lubricants and careful make-up of ways, declivities considerably less than those given by Hiley could be, and were, used in daily practice. He considered the paper to be of great value with regard to the course of events after the slider had been set in motion, i.e., after the first 2 ft. of movement. Below that, there was no consistency at all in the results obtained, as the authors pointed out. In that respect, the information given in the paper was absolutely consistent with his own experience with the ship; because, in the case of the ship, he had never found any reason for its behaviour within the first foot or two of travel. It did not seem to vary with the temperature of the day, nor with the loading on the ways, nor yet with the declivity of the ways; they could only assume that the application of the tallow and lubricant, the make-up of the launch, etc., which were manual operations, were contributing factors.

The author had referred to some work that he had done on the loads that might come upon the holding mechanism or triggers. That work was carried out because they felt that the old approximate theories of initial friction were fallacious, since they had carefully-recorded loads upon launch triggers of approximately 90 to 95 per cent. of the resolved free force of gravity, and yet had a perfectly successful launch; he felt that a warning was necessary that, when using certain modern lubricants and methods, launch triggers should be constructed so that they were able to withstand the full unrestricted resultant force of gravity and with a margin of safety, for something unexpected could happen at the last moment, when the ship must be held upon the berth and launched on another occasion. A ship started to launch long before it was realised—hours before the trigger was released—and the launching weight came up against the trigger. He was always puzzled when he read such expressions as "initial friction," "starting friction" or "stiction," and was inclined to think that something might be gained by studying the plastic theory as applied to launching lubricants, rather than applying any form of coefficient to the initial friction.

Ir. R. Voorhoeve said that, in the yard of Messrs. Van P. Smit, Jun., Rotterdam, they always carried out extensive measurements before and during every launch. They measured the creep at each point of the ways. The trigger was held by a hydraulic piston and a lever. From the velocity and acceleration, they calculated the coefficient of friction during the launch in the same way as was indicated in the paper, and obtained figures which were about the same as those given by the authors. From the measured holding forces on the trigger, however, they had arrived at a different conclusion from that of the authors. When they began to make measurements of holding force, some ten years ago, the instruments were not very exact and it was not possible to arrive at conclusions. Since the end of 1949, however, instruments had much improved, and they discovered that the holding force on the trigger was about the same as the creep force, from which they concluded that the friction at that moment was zero. He offered to send the figures to the secretary as a contribution to knowledge on the behaviour of a ship on the slipway. As soon as the ship came against the trigger there was no longer any motion, and, consequently, no friction. It was not so very strange, therefore, that the coefficient of friction at that moment was zero.

Ir. J. H. Krietemeijer said that launching observations had been made in various Dutch yards, using different types of recording units. He had himself taken measurements on six or seven ships between 1937 and 1939 at the van der Giessenor yard; and at the yard in which he was at present engaged it was the normal practice to record launchings and to produce diagrams of the type of Fig. 6 in the paper. It was worth-while to pay attention to the co-ordination of the work on launching tests by the British Shipbuilding Research Association, which set a good example to the Dutch shipbuilding industry, and he advised his Dutch colleagues to co-operate in tests on launches. The normal tests in Dutch yards were rather crude over the first few feet of travel, and they must be thankful to the authors for having explained, to some extent, the phenomena occurring at the moment of releasing the trigger. Their curve for calculating the coefficient of friction at the moment of releasing the trigger was plotted with the greatest accuracy; but, in his opinion, the degree of accuracy was too high. The movement did not start at the actual point of releasing the trigger, but much earlier. When taking away the blocks and changing over the load from the blocks on to the standing way, there were vibrations and changes of pressure—what the authors called the "creep." That creep varied with the loading and the authors used it to measure the holding force. When the weight of the ship was transferred from the blocks to the ways the same creep occurred.

* "Launching Triggers," by H. B. R. Rowell, *Trans. N.E.C. Inst.*, 1944-45.

To be sure that the coefficient of friction was as low as possible, that is to say, nearly the coefficient of friction at motion, in Dutch yards a method was used of increasing the load on the trigger before the last bilge blocks were removed. In the first stage, i.e., a few minutes before cutting the trigger wire and when all bilge blocks were still under load, they depressed the forward end of the sliding way, all slack in the ways was taken up, and there was a slight movement, the load on the trigger rising. In the meantime, the last blocks were removed and the pressure on the forward end of the sliding way was raised. When the last blocks were taken out, the actual movement had started, and at that moment the signal for launching was given. A few seconds later, the trigger was released and the ship moved instantly. Since the war they had used Esso launching greases, Basekote and Slidekote. They used three layers—two layers of Basekote and one layer of a mixture of two of Basekote and one of Slidekote. The figure for the melting of the Basekote, as given in the paper, was too low; they used 240 deg. F. They applied the Slidekote on the Basekote not as a thin layer, but in small blobs, leaving air channels in between, which serve to a certain extent as a grading of the two layers at the beginning of the movement. With regard to the testing procedure followed by the authors, he believed that the tests were made with uniform time of loading before the trigger was released. In the tests in his own yard, the time was varied before releasing the trigger and loading the ways, and they found that, the longer the ways were under load, the bigger was the holding force on the trigger.

Dr. S. Livingston Smith thought it strange that, regarding the performance of the grease throughout the operation of launching, so very little reliable information was available. The paper filled that gap in their knowledge to a considerable degree, and the authors were to be congratulated on the very careful design and execution of their tests, even though they were not made under ideally controlled conditions. The results of the tests supplied some very useful data; but the tests were made on a more or less model slipway and it was obviously desirable, as in the case of any tests done on a small scale, to compare the results with the data obtained from a full-scale launching operation. A suitable instrumentation for the accurate measurement of the forces acting during launchings and for obtaining time-distance curves had been developed by the staff of the British Shipbuilding Research Association, and already they had made some measurements on a number of ships during launching.

Results were already available, some of the ships being launched with Tallene and others with mineral greases. Good agreement with the authors' results had been obtained in the case of ships launched on Tallene, but the results with mineral greases emphasised the importance of the time during which the ship was permitted to remain on the trigger before launching. That brought him to the authors' general conclusions: to the fact that the mineral grease gave a lower coefficient of static friction and, therefore, a higher load on the triggers. He was inclined to utter a word of caution, that the time must be sufficient for that situation to develop. In fact, in their own experiments on full-size ships, they had had two cases where launching on mineral greases actually gave a higher coefficient of static friction and a lower load on the trigger than for ships launched on Tallene. That would appear to contradict the conclusion reached by the authors, but it was not a contradiction at all; it was almost a verification, because in those particular cases the ships were on the triggers for only a few moments, and consequently there was not the time available for the full development of the load on the triggers.

Another factor entered into the problem, as Sir Robin Rowell had indicated, namely, that it was reasonable to expect that the full trigger load would probably develop earlier on the short model than on the much longer ways in the full-scale launching operation. The cases he had mentioned with regard to the measurement of creep between the standing and sliding ways during the launchings indicated that movement continued up to the moment of release, which meant that the full load on the triggers had not been reached. That led to an interesting conjecture. It would appear from those results that, when mineral grease was used, the magnitude of the forces acting on the launching triggers, and the coefficient of starting friction, might be regulated at will by selecting the length of time during which a ship was left on the triggers. The longer the time, the larger would be the force on the trigger and the smaller the coefficient of starting friction. The rate of build-up of the forces on the triggers was of vital importance if that conjecture were followed farther; it had not yet been established, but it was hoped to obtain information from observations on full-scale launches, which were to be made by the B.S.R.A. staff.

Professor Ir. H. Blok agreed with Dr. Livingston Smith that an important gap had been filled in their knowledge of launching greases; but there was another important gap which had yet to be filled. Judging from the literature on the subject, it seemed that difficulties had been experienced in arriving at a more generally applicable interpretation of test results, especially as regards the relationship between the frictional performance of the greases and their rheological (flow and deformation) characteristics. He offered two suggestions to overcome the difficulty of this correlation. First, they might regard the experimental set-up used by the authors as a scaled-up model of the parallel-plate type of viscometer or plastometer, sometimes used in laboratory determinations of the rheological characteristics of greases. If more were known about those characteristics of the greases tested, such as their yield values and their trends of shearing stresses with varying rates of shear, perhaps certain of the authors' friction results, if not all, could be interpreted in a more synoptical way; they could then reach conclusions which were more generally applicable. The second suggestion was that perhaps they could achieve something by applying dimensional analysis, more or less along the lines commonly used for correlating friction determinations in oil-lubricated journal bearings with sliding speed, oil viscosity and bearing load; but before they could apply such suggestions to full advantage they should have more data about the actual flow properties of the greases used.

Mr. Brown, in reply, said that he and Mr. Ferguson were particularly indebted to Sir Robin Rowell for his very useful contribution, because their work was related to that already undertaken by him. They were not wedded to any conceptions of values of coefficients of friction. In the paper, they had certainly referred to coefficients of initial sliding friction and coefficients of static friction; those were rather terms of convenience. They also had gone back to the days of Hiley and, like most shipbuilders, relied on him for many years, but they felt that some more extensive knowledge of the subject was required. Encouraged by the B.S.R.A., they undertook the tests and eventually were led to the need to turn attention to the initial forces rather than the derived coefficients of friction. Therefore they would not like too much stress to be put on those terms, but would prefer the members to bear in mind the development which had arisen in the course of the work, of thinking in terms of the holding forces, to which, he thought, practical shipbuilders should give close attention.

There seemed a desire to associate the build-up of the forces with the time for which the loading was actually on the triggers before launching; but practice in the different shipyards varied enormously in regard to the number of blocks left below the ship before launching, and that must be a major factor in the load coming on the triggers. If there was a resistance due to the blocks left under the ship, it was bound to affect the free load remaining on the triggers; in the future study of those forces, it would be well to pay attention to that particular function. As to scale effect, referred to by Sir Robin and by Dr. Livingston Smith, undoubtedly it would be interesting to test the results with varying sizes of slider; but he did not know that it would be of great value, for the actual results from the slider seemed to lead primarily to plotting curves of coefficients of friction. Perhaps they were getting away from that to the question of the actual holding forces.

Sir Robin had mentioned the differences between the model test and the actual ship test. They realised that the model test was an idealised launch in some ways, as compared with the irregular distribution in the ship, and that again tied up with such things as the method of wedging up, and the number of blocks. Nevertheless, used as a yardstick, it had served its purpose, to point to the new development of giving attention to the initial forces. They might follow a little farther the question of variation of pressure. In the book by Sir John Biles, there was a discussion on the elastic ways as against the normal conception of rigid ways, on which most shipbuilders based their calculations. Calculating on elastic ways indicated enormous pressures, so that to get back to calculations with regard to varying pressures would be rather fruitless. Professor Krietemeijer had also mentioned that his practice had been to make a regular study of the ship results; but a study of ship results must produce quite a different approach from that of the model tests had shown the difficulty of plotting time-distance curves. It must also apply in the case of the full-size ship, and he thought it would have to be abandoned as a method of analysis of launches unless something more was known about the switch-over from the conditions at rest to the actual conditions of movement. They would reply in writing to Professor Kreitemeijer's question concerning melting temperature. It was interesting that they had had a suggestion that their figure was too high, whereas Professor Krietemeijer thought it too low. Obviously, conditions varied locally.

He was glad to have Dr. Livingston Smith's support of their work. As to the irregular results with mineral greases, he again suggested that these might be due to variations in the launch conditions, particularly in the number of blocks left below the ship. The study of the flow properties of the greases and the possible relationship to the lubrication of bearings, mentioned by Professor Blok, would be taken up, he believed, in the laboratory tests that were being made. He thought that the proposition developed in two stages: first, the practical launch—and they had a very much better idea than formerly of the launching forces—and the separate problem of the study of the greases as greases or lubricants, which, while of interest to the practical shipbuilder, was more a matter for scientists.

(To be continued.)

TRACK-LAYING AT WOODHEAD TUNNEL.—The laying of double-line rail tracks through the new tunnel at Woodhead, Cheshire, was completed by the permanent-way staff of British Railways civil-engineering department on September 30. A machine specially designed by the department for track-laying in tunnels was employed in the work, which was completed in seven weeks, nine days ahead of the time allotted. The tunnel is just over three miles long and some 20,000 tons of ballast, 1,000 tons of rails, and 13,000 sleepers were used on the job. The next stage will be the installation of electric cables, signalling equipment, and overhead wiring. It is hoped that the tunnel will be opened to electric-train services early next year.

RESTORATION OF PRIVATE TRADING IN MAGNESIUM.—The Minister of Materials, Lord Woolton, has decided, after consultation with the industry, that private trading in magnesium shall be restored on January 1, 1954. As from this date the Ministry of Materials will cease to trade in magnesium, and the Magnesium Distribution Order, 1951, will be revoked. Private importation will be permitted and applications for import licences should be addressed to the Import Licensing Branch, Board of Trade. Public trading in magnesium was reintroduced in 1951 because of the serious shortage which had developed throughout the world as a result of rearmament. Supplies are now such that the requirements of the United Kingdom can be met through normal trade channels.

THE "FLYING ARCHES" AT CHORLEY.—The "flying arches" in the railway cutting north of Chorley Tunnel, between Chorley and Buxton Junction on the London Midland Region of British Railways, form a remarkable example of the work of the early railway engineers. The cutting itself was made through difficult ground and when the line was constructed in the early 1840's the arches were built over the tracks to assist in supporting the walls which line the cutting. There are sixteen arches, each 18 in. wide and 27 ft. 0 in. in span, the centre section of each arch being built with eleven single stones capped by stone slabs to protect the mortar joints. They are now more than 100 years old, yet the only maintenance required has been the occasional pointing of the joints.

THE INSTITUTE OF METALS.

(*Continued from page* 439.)

Continuing our report of the annual autumn meeting of the Institute of Metals, held at Southport last month, we proceed with the transactions of Tuesday, September 22. Two concurrent sessions were held; we dealt with the first part of session "A," on page 438 *ante*.

Priming Paints for Light Alloys.

The second part of session "A" was devoted to a discussion on "Priming Paints for Light Alloys," based on a paper by Dr. J. G. Rigg and Mr. E. W. Skerrey. The paper was a joint contribution from the research laboratories of the British Aluminium Company, Limited, Chalfont Park, Gerrards Cross, Buckinghamshire, and the Imperial Smelting Corporation, Limited, Widnes, Lancashire. The authors stated that their paper recorded the final results obtained, after 3½ years, from tests comparing the protective behaviour of various paint primers on aluminium and magnesium alloys and mild steel in rural, industrial and marine atmospheres. The results had confirmed the indications obtained after six month's exposure, recorded in a paper published in vol. 75 of the *Journal* of the Institute (1948-49). Zinc chromate and zinc tetroxychromate were superior to iron oxide primer in protective value, although the latter provided satisfactory protection, especially of aluminium in the less severe environments. Red-lead priming paint was definitely harmful on light alloys, and especially on magnesium in corrosive environments. In the tests recorded, both types of chromate primer were found to be slightly preferable to red-lead on mild steel. Zinc chromate and zinc tetroxychromate pigments were preferred for composite structures of steel and light alloys in severe exposure conditions; iron oxide was adequate for milder conditions.

Discussion.

Mr. E. A. G. Liddiard, who opened the discussion, said that in spite of the authors' results he doubted whether it was good policy to apply ferric oxide as a protective for aluminium. If aluminium must be painted—he questioned whether it really needed painting—why not coat it with aluminium paint or use alumina as the pigment in the priming paint? Similarly, it appeared that magnesia would be preferable as a primer on magnesium and its alloys. The next speaker, Mr. A. W. Brace, thought that iron oxide should not be discarded lightly as a protective pigment in paints for coating aluminium. Particularly if a small amount of zinc chromate were added to it, it could give a high degree of protection to aluminium alloys. The whole question of paint formulation, however, needed further consideration. The method of protecting steel by paint was now fairly well established but there was little information on the behaviour of paints on aluminium.

Dr. F. A. Champion agreed that there was plenty of room for work on the technology of paints for the light alloys, but there was no evidence that iron oxide paints were harmful on aluminium alloys. Moreover, it should be remembered that the protection of composite structures of steel and light alloys needed careful treatment. Mr. Liddiard had questioned whether aluminium-alloy structures needed painting at all. In answer to this, it should be pointed out that in addition to protective treatment, structures had to be painted for decorative or camouflage purposes. A subsequent speaker, Mr. H. Silman, said that the stability of a paint was an important quality. Alumina and magnesia pigments had been suggested, but the behaviour of these in paints might not be satisfactory. A paint manufacturer wanted pigments which were reasonably easy to handle and would discard one which showed, for instance, a tendency to solidify in a tin. The whole subject of pigments and paint formulation was far more complex than appeared on the surface. The last speaker, Mr. R. J. Brown, said that the authors had said little concerning the pretreatment of metal surfaces. When components were not too large, a phosphate treatment gave a good surface for subsequent painting, but for very large structures, such as an aeroplane fuselage, etching primers gave good results. In judging painted surfaces, questions such as solar radiation and humidity in the atmosphere should be carefully considered, as tests carried out at one paint exposure station might not be identical with those conducted at another apparently similar station. In the course of a brief reply, Dr. J. G. Rigg stated that their work had shown very clearly that the zinc chromate priming paints were outstanding on all the metal surfaces tested. This was due to their action in maintaining a layer of protective oxide, such, for example, as alumina or magnesia, on the surface of metals. This might provide an answer to Mr. Liddiard's plea for the use of alumina or magnesia.

Oxidation and Sulphidation of Copper.

Session "B," over which Mr. G. L. Bailey presided, was devoted to four papers. The theme of the discussion on the first two papers was "Oxidation and Sulphidation of Copper." The first paper was entitled "The Oxidation of Copper, in the Temperature Range 200 deg. to 800 deg. C.," and was by Dr. R. F. Tylecote. It described work conducted in the Department of Metallurgy of the Royal School of Mines, London. The author stated that by means of a continuously-recording balance, the changes in weight during the oxidation of high-purity copper sheet had been measured over periods of up to 100 hours. The effect of different oxidising atmospheres, such as air, oxygen, "oxygen-free" nitrogen, and air containing water vapour, had been determined. Other factors investigated were: the effects of specimen shape, of an oxide film formed in air before high-temperature oxidation, and of recrystallisation, on the growth of the oxide on work-hardened copper. The sudden weight changes which took place under a wide range of conditions were ascribed to the relief of internal stress in the growing film, and the mode of stress-relief had been correlated with the previously determined physical properties of the film at various temperatures. The addition of moisture reduced the oxidation rate at 370 deg. C., and increased it between 420 deg. and 700 deg. C. Oxygen decreased the oxidation rate, as compared with air, between 200 deg. and 420 deg. C.; at 520 deg. C., and above, there was a slight increase. At 420 deg. C., the initial oxidation rate of wire was considerably less than that of sheet. Cold-worked sheet had initially a lower oxidation rate than annealed sheet. Annealing during oxidation, however, resulted in a final weight gain similar to that of annealed copper.

"Growth of Sulphide Films on Copper" was the title of the second paper. It was by Dr. T. P. Hoar and Dr. A. J. P. Tucker, and described work carried out in the Department of Metallurgy, University of Cambridge. The authors stated that they had investigated the growth and structure of sulphide films on copper, produced under simple conditions in liquid media. The reaction of copper with sulphur dissolved in benzene produced "cuprous sulphide" of composition between $Cu_{1.45}S$ and $Cu_{1.60}S$. The attack was not uniform; those parts of the sulphide layer which formed the most rapidly had the lowest copper content. The rate of attack increased with the sulphur concentration. The reaction of copper with dilute aqueous ammonium polysulphide solutions, for a few minutes, produced films showing interference colours, which had been used to estimate the rate of film growth. The rate was initially approximately constant with time ("rectilinear" growth), proportional to the total polysulphide concentrations, and increased by increase of the illumination of the tarnishing surface. During the later stages of growth, the rate became inversely proportional to the film thickness ("parabolic" growth), and much less dependent upon polysulphide concentration and upon intensity of illumination. The rate was increased by increases of the *p*H value of the attacking solution. When electrolytically-polished copper was tarnished with polysulphide solutions, films of different colours were obtained on each grain. On annealed material, the film on any one grain was of uniform colour and was monocrystalline.

Diffusion and the Kirkendall Effect.

The theme of the discussion on the two last papers at session "B" was "Diffusion and the Kirkendall Effect." The first of the two papers was entitled "Micrographic Aspects of the Diffusion of Zinc and Aluminium in Copper" and was by Dr. H. Bückle and Mr. J. Blin, of the Office National d'Etudes et de Recherches Aéronautiques, Paris. The authors stated that diffusion experiments carried out on brasses containing 10, 20, and 30 per cent. of zinc and on a copper-7 per cent. aluminium alloy, in contact with pure copper had confirmed the observations made by A. D. Smigelskas and E. D. Kirkendall and presented by them in a paper before the American Institute of Mining and Metallurgical Engineers in 1947. These observations were to the effect that the interface between the copper and the alloy was displaced during diffusion in such a manner that the copper expanded and the alloy contracted, and, further, that holes appeared in the diffusion zone, though on the alloy side only. In certain cases, particularly in the copper-aluminium alloy, the holes had the shape of regular octahedra.

The second of the two papers was by Mr. E. Lardner and dealt with work carried out in the laboratories of Magnesium Elektron, Limited, on "The Formation of Intracrystalline Voids in Solution-Treated Magnesium-Aluminium Alloys." The author stated that it had been observed that occasionally the solution-treatment of cast magnesium-aluminium alloys resulted in the formation of small hexagonal voids in the centre of many grains. Various attempts had been made to account for the formation of these cavities, but no satisfactory explanation had been found. In view, however, of the recent observations of similar cavities in other alloy systems, the details of the occurrence of such cavities in magnesium-base alloys assumed fresh interest. As a result of the present work it had been found that in a sample of an alloy which did form cavities, the cavity formation increased to a maximum and then eventually vanished with increasing homogenisation. It had also been found that the cavities were probably produced on cooling after solution-treatment rather than during heat treatment.

On Tuesday afternoon, visits were paid to various works. In the evening, a civic reception was held at the Town Hall. The whole of Wednesday, September 23, was devoted to visits to works and research establishments in Manchester and elsewhere. In the evening a banquet was held, by invitation of the reception committee, at the Prince of Wales Hotel, Southport.

(*To be continued.*)

TRAINING OF ELECTRICAL TESTERS.

The British Thomson-Houston Company, Limited, Rugby, have issued a booklet describing their scheme for training electrical testers. The scheme is in operation at their Rugby works and is designed to round-off a practical training for the electrical industry. The works at Rugby are large, employing approximately 10,000 people, and a wide range of electrical equipment is manufactured. The trainee, therefore, has a chance of becoming acquainted with many aspects of the industry. There are two levels of entry for applicants, one for those holding an Ordinary National Certificate (Electrical) and the other for those holding the Higher National Certificate or Diploma. The first class are normally engaged for three years, and the second for two. Efforts are made to provide the type of experience the applicant desires, but, in general, about six months will be spent on motors and control gear, and about twelve on transformers, generators or turbo-alternators. A 44-hour five-day week is usually worked, but may be varied to meet production requirements. Two weeks' holiday are allowed. Students are encouraged to attend evening classes, but day-time release is not possible. Rates of pay will be communicated on application. The works provide many facilities for recreation: there are 15 acres of sports grounds laid out for tennis, cricket, hockey, football, running and bowls. There are also badminton, swimming, shooting and radio clubs. Applications should be sent to the Head of the Personnel Department, The British Thomson-Houston Company, Limited, Rugby, and should give name, date of birth, qualifications and previous experience.

A TRANSFORMER FACTORY.

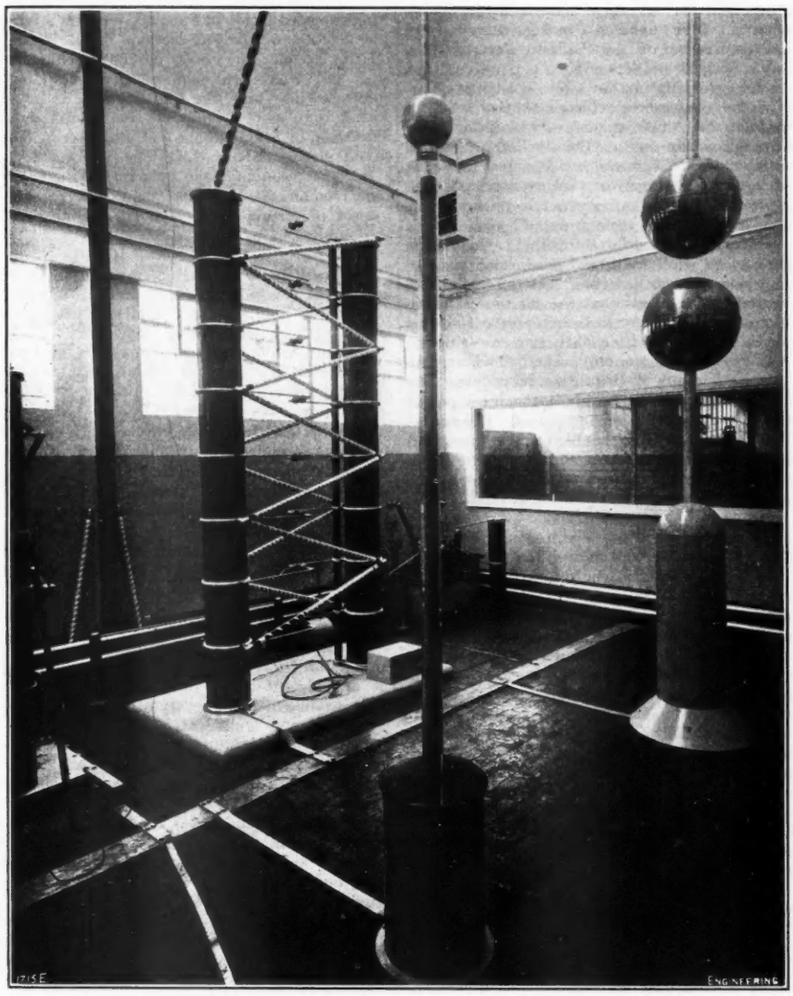


FIG. 5. 500-KV MARX GENERATOR AND TRANSFORMER.

A TRANSFORMER FACTORY.

LAST month Foster Transformers, Limited, South Wimbledon, London, S.W.19, celebrated their 50th anniversary. The firm, now one of the Lancashire Dynamo Group, was founded in 1903 by Mr. M. V. Ely, C.B.E., who is the present chairman.

The first product was a hot-wire arc lamp, and was made in a small workshop in Worple-road, Wimbledon. Metal-filament lamps with auto-transformers followed and business increased until, in 1910, the firm had to move to its present site at South Wimbledon. Transformers then became the major interest and, with their control gear, are now the only product; in 1951 the manufacture of Foster switchgear was taken over by Lancashire Dynamo Switchgear, Limited. All types of transformers and their associated gear are made, from the smallest, wound with 40-s.w.g. wire, up to units rated for 3,000 kVA at 66 kV. The Wimbledon works now employ some 900 people and a new factory has been opened at Leatherhead to deal with the fabrication of the heavier steel tanks. On a visit to both works recently we were shown over the shops, test department, etc.

All the transformers are manufactured from raw materials and there is an inspection department to check that these conform to requirements. Laminations for cores are cut from sheet for the most part, but where standard sizes are in use they are purchased ready cut. Although attempts are made at standardisation, most of the work is undertaken to customers' requirements. Nevertheless, provision is made for line production in the assembly shop. Fig. 1, on page 464, shows the smaller transformers being assembled, and Fig. 2 the larger units.

The coil-winding shop, which is shown in Fig. 3, is well equipped; it includes machines for winding toroidal coils which have been developed by the firm from a Swiss design. Coils are insulated and impregnated according to the service for which they are designed. In addition to industrial transformers and regulators, a wide range of testing equipment is made. This calls for accurate work, and a special part of the test department is devoted to making the necessary checks. The department is divided into sections placed to give the best flow of work through the shops. There is a research laboratory where work is being carried out on problems connected with improved design and construction methods. This is illustrated in Fig. 4, also on page 464. A recent addition is a high-voltage laboratory housing a 500-kV Marx impulse generator and a 300-kV transformer with ancillary apparatus. This laboratory is shown in Fig. 5, herewith.

At the Leatherhead works the heavy steel tanks are made. Arc welding is employed for fabrication, and stud welding is also used. Oil-cooling tubes of elliptical cross-section are fitted on the large transformer tanks to save space and yet give the same surface area. The tubes are bent cold in a Hilmer bending machine and are subsequently welded into the side plates.

AIR-LINER PROJECTS.

THREE new air-liner projects have been announced recently. Two of these are intended as replacements of the D.C.3 aircraft, as is the Accountant air-liner designed by Aviation Traders (Engineering), Limited, Stansted Airport, and described on page 311, *ante*. One, designed by Handley Page, Limited, Cricklewood, London, N.W.2, is an economical general-purpose short to medium range aircraft for 36/44 passengers and freight, suitable for operation from grass strips and with limited servicing facilities. It will be powered by four Alvis Leonides Major engines, each developing 870 h.p. for take-off. The aircraft is an all-metal high-wing monoplane with a single fin and rudder and a twin-wheel tricycle undercarriage. It has a wing span of 95 ft., an overall length of 70 ft. 3 in., and a height of 22 ft. 6 in. A standard fuel-tank capacity of 700 gallons will be provided, giving a still-air range of 1,500 miles at a cruising speed of 220 m.p.h., and carrying a payload of 7,050 lb. A 1,000-yard grass strip is required for take-off. The constructors estimate the direct operating costs at 1¼*d.* per passenger mile.

Percival Aircraft, Limited, Luton, Bedfordshire, are also designing a "D.C.3 replacement," to be known as the P.87. With an all-up weight of 26,000 lb., it will accommodate 36 passengers. It is to be powered by two Napier propeller turbines with pusher propellers, which, it is claimed, will result in clean lines and a high propulsive efficiency. The layout of the airframe and power plant has been designed to minimise maintenance work.

The other new project, the Twin Pioneer, by Scottish Aviation, Prestwick Airport, Scotland, is a simple 16-seat feeder-line aircraft designed for operating from the most primitive airfields. It will be powered by two Alvis Leonides 502/1 engines. The Twin Pioneer is a high-wing braced monoplane with a fixed tailwheel-type undercarriage, for easy maintenance, and has triple fins and rudder. Developed from the Prestwick Pioneer light-communication aircraft, which has exceptionally good low-speed characteristics and can take-off and land over a 50-ft. obstacle in well under 300 yards, the Twin Pioneer is fitted with Fowler-type flaps, leading-edge slats, and slotted ailerons. It is estimated that it will take-off, at an all-up weight of 13,500 lb., from a grass strip, and clear a 50-ft. obstacle, in 360 yards, and will land over a 50-ft. obstacle in less than 300 yards. A total fuel capacity of 160 gallons will be provided in wing tanks, giving a maximum still-air range (with full 3,008-lb. payload) of 620 miles, at a cruising speed of 124 m.p.h. Assuming an annual utilisation of 2,000 hours, the direct operating costs are estimated at less than 1½*d.* per passenger mile.

INSTITUTE OF TRANSPORT AWARD OF MERIT.—Sir Reginald Wilson, a member of the British Transport Commission, has received the triennial award of merit of the Institute of Transport for his paper on "The Framework of Public Transport," read at the recent congress of the Institute at Glasgow.

AIR CARGO DEPOT.—British European Airways have opened a new cargo depot on the South Bank site, in the building which formed the "People of Britain" Pavilion at the Festival of Britain, situated between Waterloo Air Terminal and Hungerford Bridge. Ramps have been installed for handling items of freight weighing up to 1 ton. During the past five years, the freight handled by the Corporation has risen from 200 tons to 1,100 tons per month.

ROAD SAFETY EXHIBITION.—At the suggestion of the Ministry of Transport, an exhibition is being arranged by the Road Research Laboratory of the Department of Scientific and Industrial Research, and will be held at the Traffic and Safety Division of the Laboratory at Langley Hall, Langley, Buckinghamshire, on Wednesday, Thursday and Friday, October 21, 22 and 23. The exhibition is part of the arrangements in connection with the national road safety week and is intended to show the progress of research work in connection with problems involving road safety. Tickets of admission may be obtained, free of charge, from the Road Research, Laboratory, Harmondsworth, West Drayton, Middlesex. Applicants should specify for which day a ticket is required and whether they wish to attend a morning session (10 a.m. to 1 p.m.), or an afternoon session (2 p.m. to 5 p.m.).

LAUNCHES AND TRIAL TRIPS.

M.S. "Themis."—Single-screw cargo vessel, with accommodation for twelve passengers, built and engined by Eriksbergs Mek. Verkstads Aktiebolag, Gothenburg, Sweden, for Wilh. Wilhelmsen, Oslo, Norway. Main dimensions: 470 ft. between perpendiculars by 65 ft. by 43 ft. to shelter deck; deadweight capacity, 10,550 tons on a draught of 27 ft. 6½ in. B. and W.-type ten-cylinder single-acting two-stroke Diesel engine, developing 11,500 i.h.p. Speed, 18 knots, fully loaded. Delivered, August 27.

M.S. "Sylvafield."—Single-screw oil tanker, built and engined by William Doxford and Sons, Ltd., Sunderland, for Hunting & Son, Ltd., Newcastle-upon-Tyne. Second of two vessels constructed for these owners. Main dimensions: 515 ft. by 70 ft. by 39 ft.; deadweight capacity, 16,700 tons on a draught of 30 ft. 1 in. Doxford six-cylinder opposed-piston oil engine, developing approximately 6,450 b.h.p. at 117 r.p.m., and a service speed of about 15 knots. Trial trip, September 3.

M.S. "Teeswood."—Single-screw cargo vessel, built by the Burntisland Shipbuilding Co., Ltd., Burntisland, Fife, for the Constantine Shipping Co., Ltd., Middlesbrough, for service on the St. Lawrence River and the Great Lakes, Canada. Main dimensions: 214 ft. 6 in. between perpendiculars by 35 ft. 4 in. by 16 ft.; deadweight capacity, about 1,550 tons on a draught of 15 ft. 8½ in.; gross tonnage, 1,246. Five-cylinder oil engine, developing 800 b.h.p. at 250 r.p.m., constructed by British Polar Engines, Ltd., Glasgow. Speed, 10½ knots. Trial trip, September 5.

S.S. "Ariana."—Single-screw cargo vessel, built and engined by William Gray & Co., Ltd., West Hartlepool, for Rederibolaget Re-Be, Abo, Finland. Main dimensions: 406 ft. between perpendiculars by 56 ft. by 36 ft. 4½ in. to shelter deck; deadweight capacity, about 8,600 tons on a draught of 24 ft. 11 in. Triple-expansion steam engine working in conjunction with a Bauer-Wach exhaust turbine, constructed at the shipbuilders' Central Marine Engine Works. Steam supplied by two oil-fired boilers. Service speed, about 11½ knots. Launch, September 10.

M.S. "Camilla."—Single-screw oil tanker, built and engined by Aktiebolaget Götaverken, Gothenburg, for the Rederi AB Transmark, Gothenburg, Sweden. Main dimensions: 555 ft. overall by 66 ft. by 39 ft. 3 in.; deadweight capacity, 17,400 tons on a draught of 30 ft. 2½ in. Götaverken nine-cylinder two-stroke single-acting Diesel engine, developing 6,750 b.h.p. at 112 r.p.m. and a speed of 14½ knots, fully loaded. Launch, September 15.

M.S. "Britta."—Single-screw oil tanker, built and engined by Harland and Wolff, Ltd., Govan, Glasgow, for Mr. A. Mathiesen, Oslo, Norway. Main dimensions: 540 ft. between perpendiculars by 73 ft. by 39 ft. 3 in.; deadweight capacity, about 18,500 tons. Harland-B. and W. six-cylinder two-stroke single-acting opposed-piston oil engine. Trial trip, September 14, 15 and 16.

M.S. "Marianne."—Single-screw oil tanker, built and engined by the Eriksbergs Mek. Verkstads Aktiebolag, Gothenburg, Sweden, for the Aktiebolaget Navigare, Stockholm, Sweden. Main dimensions: 526 ft. between perpendiculars by 69 ft. 9 in. by 39 ft. 3 in.; deadweight capacity, about 18,000 tons on a draught of 30 ft. 5 in.; oil-tank capacity, about 860,000 cub. ft. Eriksberg-B. and W. nine-cylinder two-stroke single-acting Diesel engine, developing 9,000 i.h.p. and a speed of 15½ knots, fully loaded. Launch, September 17.

M.S. "Hazelmoor."—Single-screw cargo vessel, built and engined by R. and W. Hawthorn, Leslie & Co., Ltd., Hebburn-on-Tyne, County Durham, for the Moor Line, Ltd. (Managers: Walter Runciman & Co., Ltd.), Newcastle-upon-Tyne. Main dimensions: 423 ft. between perpendiculars by 58 ft. by 29 ft. to upper deck; deadweight capacity, about 9,540 tons on a draught of 25 ft. 8½ in.; gross tonnage, 5,580. Hawthorn-Doxford four-cylinder opposed-piston combined-stroke oil engine, developing 3,300 b.h.p. at 108 r.p.m. and a service speed of about 13 knots. Launch, September 22.

Light Vessel No. 14.—Built by Philip & Son, Ltd., Dartmouth, for the Corporation of Trinity House, London. Twenty-second light vessel constructed for the Corporation. Main dimensions: 130 ft. by 25 ft. by 15 ft.; gross tonnage, 350. The lantern contains six 500-watt lamps, giving a beam visible for from 10 to 12 miles in clear weather. Launch, September 22.

S.S. "Nuddea."—Single-screw cargo vessel, built by Barclay, Curle & Co., Ltd., Whiteinch, Glasgow, for the British India Steam Navigation Co., Ltd., London, E.C.3. First vessel of a new series for these owners. Main dimensions: 514 ft. by 67 ft. by 42 ft. to shelter deck; gross tonnage, 9,800; refrigerated-cargo capacity, 30,000 cub. ft. Parsons steam turbines with double-helical gears; the high-pressure turbine driving through double-reduction gearing, and the intermediate-pressure and low-pressure turbines through single-reduction gearing. Steam supplied by two oil-burning water-tube boilers. Service speed, 16½ knots. Launch, September 23.

LABOUR NOTES.

Many matters of great concern to industry generally, in addition to those of mainly political importance, were debated during the five-day annual conference of the Labour Party, which opened at Margate on September 28. In his address to the delegates, Mr. Arthur Greenwood, the chairman of the conference, referred to the need for maintaining full employment and the living standards of all workpeople in Britain. The fact had to be faced that the world had changed and that no one owed the people of this country a living. In future, we all had to pay our own way. The contemporary British scene and the spectacle of a sick economy did not go well together. Unemployment was low, while industrial production and the nation's gold reserves had risen. At the same time, it was generally realised that the margin of safety was narrow and that any fresh crisis respecting this country's foreign trade could have a crippling effect on the national economy, thereby endangering the living standards of Britain's workpeople. The solution was to be found mainly in the development of agriculture and the basic industries. The sinews of British workers must be backed by more and better machinery, and every effort must be made to increase the export of capital equipment to the nations of the sterling area.

Acceptance of the Party's statement of policy, *Challenge to Britain*, was moved, on the opening day, by Mr. J. Griffiths, chairman of the Party's policy committee. He said that the industrial problems confronting Britain at the present time called for the preparation of a major overall plan for the reconstruction of the nation's economy. Everything depended on the working of the basic industries. If the efforts of the Party failed to secure the requisite expansion in production, all else would be futile. Special pains would be taken by any future Labour Government to increase the output of coal, to develop the nation's fuel and power policy, and, especially, to save coal from all unnecessary waste. Public ownership of the steel industry was regarded as essential. The necessary expansion of that industry could not be secured without it.

Among the amendments to the statement dealt with on the opening day was one relating to the Party's attitude to the basic industries. This reaffirmed Labour's belief in the nationalisation of industries generally as an effective instrument of economic progress, demanded that de-nationalised industries should be returned to public ownership without compensation, requested that owners of further industries to be nationalised should be compensated by a life interest in the undertaking, and asked that all nationalised industries should be subjected to Parliamentary control. Sir William Lawther, representing the National Union of Mineworkers, stated that his union had asked that its members should not be subjected to any such thing as Parliamentary control. It would be absolutely wrong.

Speaking on behalf of the London Labour Party, Mr. Herbert Morrison said that the Parliamentary Labour Party had given most careful thought to the question of re-nationalisation without compensation and had announced that they would not pay a second time for the same thing. That was not quite the same, he said, as a categorical declaration that there would be no compensation. At present, questions about nationalised concerns could be asked in Parliament and sometimes were, but there would only be a mess if endeavours were made to bring such undertakings under meticulous Parliamentary control in the same way as the Post Office. After other speeches, the amendment was rejected by a substantial majority. An amendment asking for an investigation into the possibility of establishing a coal marketing policy and into the advisability of marketing coal, gas and electricity together was carried after a brief discussion.

Various amendments to the section of the statement relating to the re-planning of industry were put forward on the second day of the conference, and, if carried, would have committed a future Labour Government to the nationalisation of land and of many branches of the engineering and shipbuilding industries. A delegate representing the Amalgamated Union of Foundry Workers advocated the deletion of the sub-sections of the statement relating to machine tools, mining machinery, aircraft, heavy electrical engineering, shipbuilding and ship-repairing, and the substitution of a clause stating that, as the comprehensive plan of the Confederation of Shipbuilding and Engineering Unions would give a Labour Government power to build a Socialist economy, the principle of nationalisation, recommended by that plan, was accepted in respect of certain sections of the engineering and shipbuilding industries.

The sections of the engineering and shipbuilding industries referred to were aircraft, agricultural machinery, builders' and domestic castings and metal fittings, coalmining machinery, electrical equipment, heavy electrical engineering, locomotive-wagon manufacture and repair, machine tools, marine engineering (including shipping, shipbuilding and ship-repairing), motor vehicles, radio, textile machinery, and foundry equipment. This amendment was seconded by Mr. Jack Tanner, representing the Amalgamated Engineering Union. A delegate representing the Association of Engineering and Shipbuilding Draughtsmen proposed that the principal firms engaged on the manufacture of aircraft engines and air frames should be brought under public ownership. Among other proposed amendments was one to nationalise the "whole of the armaments industry."

The debate on these amendments was continued on the third day of the conference. Referring to the amendment of the Foundry Workers, Mr. T. Williamson, general secretary of the National Union of General and Municipal Workers, expressed the view that its introduction was premature and pointed out that the Confederation's "Plan for Engineering" was still under consideration by the Confederation, the Trades Union Congress, and the various unions concerned. Another critic, Mr. Arthur Deakin, C.H., general secretary of the Transport and General Workers' Union, said that he wished to indicate how firmly opposed to the proposals that had been put forward were the hundred thousand members of his union represented in the engineering and shipbuilding industries. This had been amply affirmed recently by more than 800 rank-and-file delegates at a union conference.

His union, Mr. Deakin stated, was completely opposed to the so-called plan of the Confederation. They believed the plan to be entirely inadequate to the needs of the country in dealing with these vital and important industries. He condemned the plan as a "mumbo-jumbo of meaningless words and phrases," and said it was regarded by his union as a most likely means of crippling the prospects of the engineering and shipbuilding industries in relation to the nation's needs at the present time. On a card vote, the various amendments referred to above were rejected by substantial majorities. Armaments, education, the health services, and a wide range of political and domestic matters were dealt with during the remaining sessions.

An outline of the proposed pension scheme for adult railwaymen and other adult male employees in the wage-earning grades of the British Transport Commission is contained in the October issue of *The Locomotive Journal*, the official magazine of the Associated Society of Locomotive Engineers and Firemen. The scheme is designed to provide a basic weekly pension of 30*s.* at the age of 65, after a minimum membership of 40 years. Members of the permanent staffs in the grades concerned, who are 21 years of age or over, and who have been employed by the Commission for at least a year, will have the option of joining the scheme when it comes into operation, provided that, by the time they reach the age of 65, they will have been able to complete at least 20 years' continuous service with the Commission or their predecessors. Employees who are unable to complete 40 years' membership will receive smaller pensions.

DISTRICT HEATING.*

By A. E. MARGOLIS, Dipl. Ing.

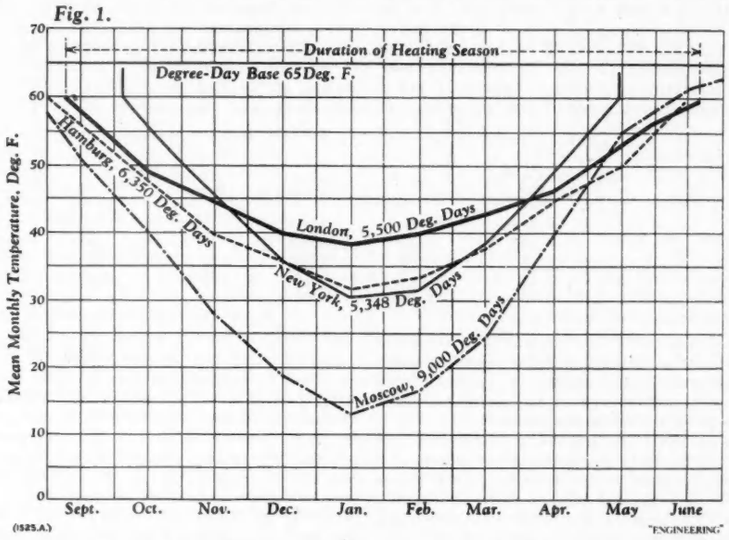
THE term district heating is applied to a centralised supply of heat to a group of buildings or section of a town. The final aim of district heating is to extend the supply of heat to the area of a whole town, similar to the supply of cold water, gas or electricity. The general adoption of district heating will raise the standard of heating and living, improve the hygienic conditions and amenities and save great quantities of coal, which is so vital for our industrial and economic life.

The development of district heating depends upon the fulfilment of two basic conditions: (*a*) reliability of service, and (*b*) economy of operation. (*a*) The reliability of district heating is greater than that of other services because the mains are provided with expansion devices and placed in conduits. An interruption of service by a fracture or dislocation of mains due to lack of expansion facilities or movement of the soil, as in the case of cold-water or gas pipes, is out of the question. Moreover, an interruption of the supply of water, gas or electricity causes a great inconvenience or even a calamity, whereas an interruption of the heat supply for an hour or two hardly affects the consumer. In addition, any repairs of a district heating supply system, should they be necessary at all, can be carried out during the night because district heating is essentially a day-time service. (*b*) The economy of district heating depends mainly upon the saving of fuel. The advancement of district-heating engineering in recent years, particularly in regard to combined heat and power generation, has considerably increased the savings and thus widened the economic basis of district heating. Direct heat supply from boilers eliminates much of our present waste of fuel; but only by co-ordination of heat and power generation on a scientific basis, utilising the high-temperature heat for power generation and the low-temperature heat for heating purposes, can the great waste both of domestic fuel and of that caused by condensing stations be completely eliminated. This double saving in fuel makes large-scale development of heat-electric generation and district heating economically possible, because the cost of electricity generation is reduced and the heat can be supplied at a lower cost (including capital charges) than by any conventional method of heating.

The magnitude of the problem can be demonstrated by the following theoretical consideration. According to the Ridley Report, 60,000,000 tons of coal were used in Great Britain in 1951 to provide directly or indirectly domestic heat and power services. The coal consumption for generation of electricity, for lighting and power, is comparatively small, and it hardly exceeds 10 per cent. of the total domestic consumption. Taking an average calorific value of 11,500 B.Th.U. per pound and an average thermal efficiency of 30 per cent., the total quantity of heat supplied in 1951, for domestic purposes, was of the order of $11{,}500 \times 2{,}240 \times 0{\cdot}3 \times 60 \times 0{\cdot}9 \times 10^6 = 417 \times 10^{12}$ B.Th.U.

The total quantity of electricity generated at steam power stations owned by the British Electricity Authority in the year ended March 31, 1952, was 58,700 million kWh. The average generating efficiency was in the order of 22 per cent., but even assuming modernised power stations in the whole country with an average exhaust heat output of 10,000 B.Th.U. per kWh, the total quantity of exhaust heat which could be made available for heating purposes would amount to approximately 587×10^{12} B.Th.U. Consequently, even under ideal conditions of electricity generation, more exhaust heat could be supplied for domestic purposes than is actually required at present. The difference of 170×10^{12} B.Th.U. is more than sufficient to cover the heat losses and the extra coal required for back-pressure generation as compared with a condensing plant. The conclusion can be drawn that, with scientific management of our fuel resources and with the general introduction of heat-electric generation, 54 million tons of coal used for domestic heating in 1951, and progressively more in years to come, could be saved. True, not all homes can be provided with central heating and district heating, but, on the other hand, additional millions of tons of coal could be saved by the conversion of the existing central-heating plants of public buildings, offices, commercial buildings and factories from individual heat generation to district heating with heat-electric generation.

Fig. 1.



The magnitude of the social and hygienic problem of district heating has been shown by the author in his contribution to your Conference in 1942, under the heading "Improvement of Climatic and Living Conditions by Public Heat Supply." The London fog disaster of last December, comparable in its effects with the violent epidemics of the past, should be a warning against the misuse of coal. More recently, the direct and indirect damage caused by smoke has been estimated by Dr. A. Parker, Director of the Fuel Research Station of the D.S.I.R., at 50*l.* million annually.

NEED FOR DISTRICT HEATING.

These examples showing the waste of fuel and its evil effects on housing and living conditions emphasise the urgent need for district heating. In the light of the advance of science and engineering, the low standard of conventional methods of heating seems amazing and is most deplorable. The predominant method of heating in this country is still by means of open fires as it was 100 years ago, with an excellent efficiency in pollution of the air and blackening of our towns and cities, but with a very poor efficiency in coal utilisation. The use of gas and electric fires cannot be more than a palliative of the heating problem on a nation-wide scale because these methods of heating are both too expensive for the great masses of the people and too wasteful in fuel consumption. The restoration of the purity of the air in urban areas, together with the urgent need for fuel economy, both call for the application of district heating. The burning of coal is a complicated physical and chemical process and the highest efficiency of generation of heat and also of smoke prevention can only be obtained by burning it in large heat-electric stations with up-to-date equipment and with a specialised staff.

The need for district heating in this country is much greater than on the Continent. Here, the general standard of heating is poorer, the waste of coal is more serious and the smoke nuisance is on such a scale that it creates a problem of considerable national importance. The position can be summarised with the following words of the Simon Report presented by the Minister of Fuel and Power to Parliament in March, 1946. "We are using excessive quantities of coal; we are providing inadequate heating in the houses; we are pouring out masses of soot and tar into the atmosphere. In our view we cannot afford to maintain our low standards of heating; we cannot afford to continue to depress and destroy the life of our cities by smoke pollution; we cannot afford to waste our limited national coal resources." The serious situation of the fuel position was lately disclosed by the Ridley Report. It appears that without drastic measures a fuel catastrophe can hardly be avoided. Rationing of fuel for heating is a great inconvenience, but rationing of fuel for electricity generation, as suggested by the National Coal Board, may well distort the whole structure of economic activities in this country.

By co-ordination of heat and electricity generation the present great waste of fuel for heat and electricity supply can be substantially eliminated. Each service by itself is wasteful in fuel consumption, but when combined, the fuel consumption is reduced to a minimum. An overall thermal efficiency of 80 or 85 per cent. is obtainable, comparable with the efficiency of hydro-electric power generation. The national value of co-ordinated heat and power generation will, however, be much greater than that of hydro-electric power generation because considerably more coal is saved and at a lower capital cost, and in addition, a new ideal heating service is created which will provide more comfort and better hygienic conditions for the urban population.

The average overall thermal efficiency by all heating methods, including central heating, in this country is approximately 35 per cent., as compared with about 50 per cent. on the Continent. For the supply of the same quantity of heat we need, therefore, $(50 - 35)\,\frac{100}{35} = 43$ per cent. more fuel than on the Continent. As compared with district heating with straight heat supply with an overall efficiency, for generation and distribution, of 60 per cent., we now consume $(60 - 35)\,\frac{100}{35} = 71{\cdot}5$ per cent. more fuel; and a saving of $(60 - 35)\,\frac{100}{60} = 41{\cdot}7$ per cent. is possible. With heat-electric generation more than half of the present total fuel consumption for heat and electricity generation can be saved.

The popular conception that district heating is economically justified in the United States with their hard winters but not for our milder climatic conditions is without foundation; exactly the opposite is the case. Fig. 1 shows the mean monthly outdoor temperatures for New York, London, Hamburg and Moscow. The heating requirements are in proportion to the areas between the temperature lines and the base line, and they are expressed by the number of degree-days. The graphs show that for the same base temperature of 65 deg. F. the heat demand for space-heating in London with 5,500 degree-days is greater than that in New York, which has only 5,348 degree-days. True, in this country the rooms are heated to a

* Paper read before Section G of the British Association at Liverpool, on Monday, September 7, 1953.

lower temperature than in New York, and for public buildings and offices an indoor temperature of 65 deg. F. and a degree-day base of 60 deg. F. is recommended, which gives for London only 3,775 degree-days.

The economy of district heating depends, however, not only upon the quantity of heat supplied but also to a very large extent upon the annual load factor. Table I shows the relative annual load factors for several cities, which can be calculated from the number of degree-hours and the maximum temperature-rise for which the central heating installations are specified. It demonstrates the fact, which has so far not been appreciated, that the load conditions for space-heating in this country are more favourable than in New York, Hamburg or Moscow, even for a degree-day base for London of only 60 deg. F., as compared with a degree-day base of 65 deg. F. for the other cities. The great demand for domestic hot water further improves the economic position of district heating in this country.

The degree-day base of 60 deg. F. might be disputed as too high for dwellings. It is difficult to predict the future standard of heating in this country. The introduction of central heating has definitely improved the standard of heating, and for offices an indoor temperature of 65 deg. F. is almost general. The Industrial Health Research Board of the Medical Research Council recommends for individuals doing light work an indoor temperature in winter of 65 deg. F. It does not appear likely that people working in comfortably heated offices and factories will, in the future, be satisfied with a lower standard of heating in their homes. From the standpoint of national health the better heating of homes is even more important than that of offices and factories, because of the greater tendency to illness due to dampness, especially of bedding.

The general trend for better heating cannot be stopped and it is likely that in years to come the Continental standard of heating with 65 deg. to 68 deg. F. in living rooms and 60 deg. F. in bedrooms will be generally accepted. Owing to the changeable weather conditions, central-heating installations in this country are operated almost exclusively by low-pressure hot water at a moderate temperature. Hot-water distribution can therefore be applied which facilitates the co-ordination of heat and power generation. Turbines with very low back-pressure can be used and the heat and power loads can be balanced by hot-water storage. The output of electricity is thereby increased and the economy of heat-electric operation improved. It is further improved in this country by the growing application of panel heating, operated with quite low water temperatures.

Historical Review of District Heating.—The first district-heating plant was installed in Lockport, N.Y., U.S.A., in 1877. This system attracted considerable interest in the United States and in the following years numerous district-heating systems were installed. The first district-heating plants used live steam for heat distribution; this was but natural, because the development of district heating started a few years earlier than that of electricity supply. The rapid growth of electric lighting and electric power stations in the following years, which at that time were built with steam engines exhausting to the atmosphere, encouraged many towns to take up district heating with exhaust steam. According to the *District Heating Handbook* of the National District Heating Association of 1951, there are now several thousand district heating schemes in the United States, including those supplying institutions, industrial heating projects and groups of public buildings. In 1949 there were nearly 300 district heating schemes of a commercial nature privately owned and publicly operated.

The early electricity generating stations were usually located in the vicinity of the business areas, and it was a comparatively easy matter to make use of the available exhaust steam for heating buildings in the neighbourhood. There was no need to return the condensate and the balancing of the heat and power loads was a simple matter. With the rapid growth of the electricity demand by the end of the last century, the old primitive power stations were hopelessly outpaced by large condensing stations. Such stations were located so as to best meet the requirements for cooling water and fuel delivery, which were economically more important than the heat supply to a small section of the town. In consequence, many of the older district-heating plants served by steam engines, had either to close down or change over to live-steam distribution. Out of 17 district-heating plants which the author visited in the United States in 1925, only four plants generated electricity.

According to the operating statistics of the National District Heating Association in the United States for 1947, the total annual quantity of exhaust or bled steam sold by 59 reporting companies amounted to $6{,}755 \times 10^6$ lb., or 12·5 per cent. of the total steam sold of $54{,}415 \times 10^6$ lb. The average annual load factor of the electricity generating sets was, in that year, only about 14·3 per cent., which indicates that many of the back-pressure sets were not in operation. Owing to the great predominance of live-steam distribution, the saving in fuel by district heating in the United States is insignificant. The large boiler plants are working with a high thermal efficiency, but the heat losses of the distribution systems are considerable and the overall thermal efficiency of heat supply seldom exceeds that of a well-operated local central-heating plant. The saving in coal by combined heat-electric generation is generally appreciated, but at the low annual load factor of district heating and the low cost of coal before the war this saving was not sufficient to cover the higher operating costs, and the higher capital charges of the small heat-electric stations, or even of the additional back-pressure plant in a condensing station.

TABLE I.—Relative Annual Load Factors of Space-Heating.

City.	Degree-Day Base, Deg. F.	Number of Degree-Days.	Number of Degree-Hours.	Temperature Rise, Deg. F.	Annual Full-Load, Hours.	Annual Load Factor, Per Cent.
New York	65	5,348	128,000	70	1,830	20·9
London	65	5,500	132,000	40	3,300	37·7
	60	3,775	90,600	35	2,590	29·6
Hamburg	65	6,350	152,000	63	2,410	27·5
Moscow	65	9,000	216,000	90	2,400	27·4

Up to the end of the first World War there was in the United States a great number of plants of a commercial nature with hot-water distribution, many of which utilised exhaust steam from power stations. The number of such plants has decreased steadily and to-day there are only a few left. The reason is the ever-increasing number of sky-scrapers everywhere depending on steam heating because, on account of the height of the buildings, they could not be served from the existing low-pressure hot-water distribution systems. These plants had, therefore, to change over in the course of years to steam distribution, both because of the tall buildings, and because of the difficulties in metering the heat supplied by hot water. Hot-water distribution is, however, becoming popular again for the heat supply to housing estates.

By far the largest district-heating plant, actually the largest in the world, is in New York, and it supplies the down-town and up-town sections of Manhattan Island. Heat is supplied to consumers by means of steam at a pressure of from 125 to 165 lb. per square inch gauge, and it is remarkable that some consumers still take steam for electricity generation. In 1947, the total steam supply to consumers amounted to 15,000 million lb., and for the generation of steam about 900,000 tons of coal were burned in that year.

The general impression of the American district heating plants is overwhelming. The visitor is particularly impressed by the large boiler plants, many of which resemble in size and equipment those of modern electricity generating stations. One of the boilers of the Kipp's Bay plant, which is the largest in New York, has a capacity of 850,000 lb. per hour, which is larger than any boiler unit in Great Britain at present. More surprising is the fact that the steam is seldom utilised for electricity generation and that the great quantities of condensate are mostly not returned at all. The demand for live steam for heating and other purposes explains the economic limitations of district heating in the United States. The capital expenditure for the boiler plant is heavy and usually exceeds the cost of the distribution system. The total capital charges and the fuel cost, as well as the operating and maintenance cost of boiler plant, have to be charged to the cost of heat and this reduces the competitive position of district heating compared with local boiler plants. The low cost of oil for central-heating boilers before the war has now further weakened the economic position of district heating in the United States.

In contrast with the American development, district heating in Europe has been based predominantly on combined heat and power generation. This development was facilitated by the great shortage and high cost of coal after the war of 1914-18. Saving in fuel was the overriding consideration and the greatest economy could be attained by district heating with exhaust heat supply. The development of district heating in Europe was started in Germany, where the shortage of coal after the first World War was particularly acute. At that time the predominant method of heating buildings on the Continent of Europe was by slow-combustion stoves with a thermal efficiency of 40 to 50 per cent. The installation of central heating achieves a higher standard of comfort because more heat is supplied but only a little fuel is saved as the efficiency of central-heating boilers is only 60 to 75 per cent. Moreover, the installation of central heating in an existing building involves many difficulties, and the number of central-heating installations in use is a small percentage of all habitable buildings. District heating plants, as a rule, had to be designed for the heat supply of existing central-heating installations. This explains why district heating had at first to be limited to favourable areas of a town with an adequate proportion of existing central-heating installations. The conditions improved in the course of years because central heating became more popular. All new office buildings and nearly all new blocks of flats erected after the 1914-18 war were fitted with central heating.

In Hamburg, the author initiated in October, 1921, a district-heating plant from the oldest electricity generating station in the town. This was from the Poststrasse station, conveniently situated in the centre of the old town. In 1924, a second power station, and in 1929, a third power station, was taken over by the District Heating Company. In that year all rights for district heating were acquired by the Electricity Company, and the Bille power station, at a distance of 2·7 miles from the Poststrasse station, was put into service for heat supply. The heat-distribution was by means of steam because of the many existing steam-heating plants, but in 1929, a hot-water distribution system was added and included a large capacity hot-water accumulator for balancing the loads. Finally, in 1933, the heat-distribution system was connected to a comparatively modern power station located in Tiefstack outside the built-up area of Hamburg, with a generating capacity of 85,000 kW, but with a working pressure of only 200 lb. per square inch gauge. Two new high-pressure boilers, each with a steam output of 220,000 lb. per hour and a working pressure of 1,700 lb. per square inch gauge, and two back-pressure sets of 11,000 kW each were installed. The exhaust steam at the pressure of the old boiler plant of 220 lb. per square inch gauge was transmitted partly to the existing condensing sets and partly over a distance of 2·2 miles, with a 28-in. dia. steam main, to the Bille power station, where it was used again for electricity generation, and the exhaust steam, at about 40 lb. per square inch gauge, was supplied to the network of the district-heating system. The existing back-pressure set in the Bille station had an output of only 4,000 kW, but the back-pressure generating

DISTRICT HEATING.

Fig. 2. DISTRICT HEATING IN HAMBURG

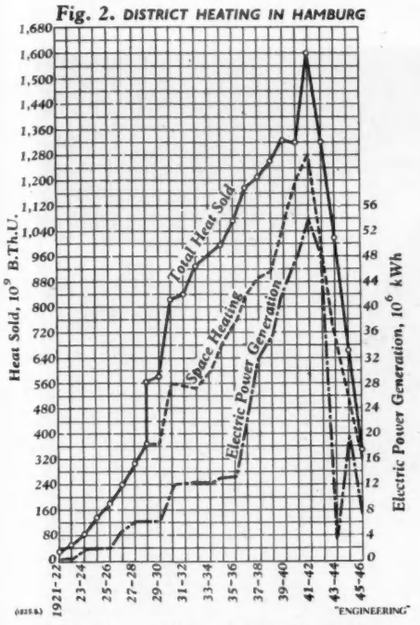
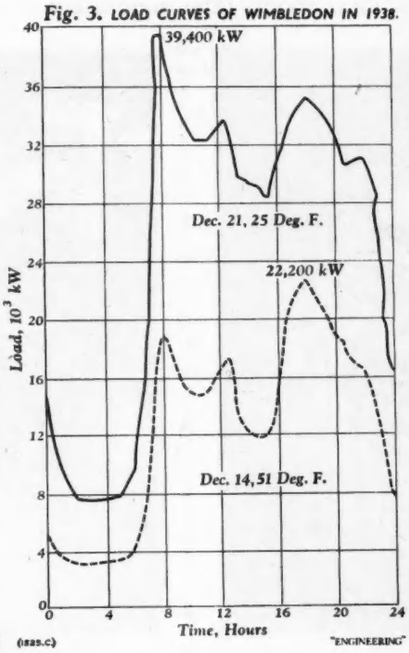


Fig. 3. LOAD CURVES OF WIMBLEDON IN 1938.



capacity of the station could be increased to a total of about 20,000 kW. After the erection of the steam transmission main from the Tiefstack power station, the old boiler plant of the Bille station was taken out of commission. The rapid development of district heating in Hamburg is indicated by the diagram Fig. 2, showing the growth of heat supply and electricity generation from 1921-22 to 1945-46. The great fall of the heat supply and electricity output in 1941-42 was due to a heavy air-raid in 1942 in which most of the buildings served by district heating were destroyed. The catastrophic shortage of coal in the following years reduced the supply of heat even more. Since the end of the 40's however, the growth of the heat supply was most remarkable and in 1952, $3{,}400 \times 10^9$ B.Th.U. were sold, including process heat from a new heat-electric station at Harburg, near Hamburg, and altogether 60×10^6 kWh were generated in a combined heat-electric cycle.

District heating has been adopted to an appreciable extent in other European countries, such as Denmark, Holland, France, Czechoslovakia and Switzerland. Some Danish plants are supplied with waste heat from Diesel engines. The district-heating plant at Zürich is served from the heat-electric station at the Technical University and is supplemented by three heat-pump units for a total capacity of 24×10^6 B.Th.U. per hour. Like Hamburg, the district-heating plant in Paris, has in recent years been extended with a high-pressure plant from the Ivry power station for the supply of steam to the existing generating sets with a moderate pressure and the network of the district-heating plant in the central part of the city, at a distance of 2·9 miles.

A very remarkable development towards heat-electric generation has meanwhile also taken place in New York, U.S.A. The Consolidated Edison Company, of New York, had a programme of modernisation at their Waterside stations, which is probably now completed. Ten boilers with a combined capacity of about 6,000,000 lb. per hour of steam at 1,200 to 1,600 lb. per square inch were installed. There are to be six topping turbo-generator units with a combined rating of 336 MW and eight low-pressure turbo-generator units with a combined rating of 322 MW. The exhaust steam of the high-pressure sets is at about 200 lb. per square inch gauge, and from the intermediate headers steam is supplied to the New York Steam Corporation for district heating.

The development of district heating in the Soviet Union has been most impressive. It was started on a very small scale in Leningrad in the winter of 1924-25. At the beginning of 1939, the total number of district-heating plants amounted to 166. Most of the plants provide combined heat-electric generation, and the total electricity generating capacity with back-pressure or pass-out sets amounted in 1939 to 1,743,000 kW.

Centralised Heat Supply by Electricity and Gas.—Electrical and gas engineers often claim that a centralised supply of heat is already being provided by electricity or gas and there is no need for district heating with steam or hot-water distribution. Gas and electric heating, in spite of their convenience, however, cannot solve the heating problem on a nation-wide scale because they are too expensive for most consumers; they consume greater quantities of fuel; and in the case of electricity, they are frequently used at times of system maximum demand and thus necessitate heavy capital expenditure for a very low annual load factor. Gas and electric heating were introduced in this country owing to the inefficiency of coal fires.

Heating loads were favourable for the gas and electricity undertakings in the past, when the demand could easily be met from existing plants. These loads improved the annual load factor and special low rates could be introduced for heating. In recent years, however, conditions have changed completely. Most of the gas and electricity undertakings now have a greater heating load than they can meet and additional supply of heat can be given only when new plants are provided. The plant capacity required for the further introduction of gas and electric heating to any appreciable extent is considerable, and the capital charges have to be allocated to heating consumers only. On cold days the heating load in the morning increases as quickly as the lighting load, but the maximum demand created is of much greater magnitude. Fig. 3 demonstrates the influence of the heating load on the electricity supply in Wimbledon during the cold spell in December, 1938. From December 14 to 21, 1938, the outdoor temperature dropped from 51 deg. to 25 deg. F. and, in consequence, the morning peak increased by more than twice, i.e., from 19,000 kW to 39,000 kW, in spite of the fact that even at 51 deg. F. outdoor temperature some heating load must have been on. In this case, the extra demand could be met by the grid, but it is obvious that the additional turnover from the sale of electricity was negligible as compared with the cost of plant. If all the undertakings in Great Britain were as successful as Wimbledon in developing the heating load, the total electricity-generating capacity of the country would have to be increased by about 100 per cent.

According to P. Schiller, electric space-heating had, before the war, a poor annual load factor of the order of 13 per cent.* With increasing use of electric heaters for topping-up space heating this load factor will steadily decrease. In contrast with gas, electricity cannot be stored. Electricity-generating capacity must therefore be large enough to meet the maximum simultaneous demand on the system. This increases the capital expenditure for plant and in consequence the cost of electricity to consumers is excessive. The present tendency of electrical engineers is to reduce the heat consumption for space heating to a minimum by better insulation of the building structure and by decreasing the ventilation as much as possible.† This curtailment is in contradiction to the normal requirements of heating for comfort and health as provided by central heating. In spite of the extreme limitation of the annual heat input to only 175 therms, it appears that an all-electric house would require an extra expenditure of 10*l.* 7*s.* 0*d.* per annum which for the 13,000,000 houses in Great Britain amounts to an addition of 140*l.* million annually to the cost of electric heating as compared with the fuel costs for the conventional methods of heating.

The suggested 1·5-kW heaters are neither sufficient for continuous heating nor the suggested heat storage. The only remedy appears to be the introduction of heat-electric generation with large-capacity hot-water accumulators for balancing the heating and electricity loads as referred to later. The balancing effect of large-capacity hot-water accumulators upon electricity generation can be compared technically with the balancing effect of gasholders upon gasworks, but it is of much greater economic magnitude because of the much greater heat-storage capacity per unit of volume and because of the double influence on heat and electricity generation. Combined heat-electric generation is needed firstly, for the economic introduction of district heating and secondly for the further development of electricity supply giving the greatest saving in fuel.

(To be continued.)

ANCILLARY EQUIPMENT FOR GAS-HEATED PLANT.—A review of available ancillary equipment for operating and controlling gas-heated plant, and recommendations on selection, installation and maintenance, are contained in Report No. 538/53 D 034 of the Industrial Gas Development Committee, issued by the Gas Council, 1, Grosvenor-place, London, S.W.1.

ATMOSPHERIC DUST RESEARCH.—An investigation of the problems arising from the increasing amount of dust in the atmosphere is being carried out by a research group from Wolverhampton and Staffordshire Technical College. New bio-chemical methods are being applied by the group, who are concentrating on the chemical, physical and physiological aspects of the problem.

REVIEW OF A.S.T.M. RESEARCH.—The American Society for Testing Materials announce that reprinted copies of the *Review of ASTM Research*, as published in the *ASTM Bulletin* for December, 1952, and January and February, 1953, are now available gratis from the offices of the Society, 1916, Race-street, Philadelphia 3, Pennsylvania, U.S.A. The review summarises the work of the various technical committees of the Society.

REMOVAL OF RESTRICTIONS ON USE OF MOLYBDENUM.—The Minister of Supply has issued a Direction removing the restrictions on the use of molybdenum in alloy steel. It took effect from September 21, 1953. Restrictions on the use of nickel and molybdenum in certain forms of alloy steel were imposed on June 2, 1952, owing to their scarcity. Improved supplies of molybdenum have enabled the restrictions on this material to be removed. The restrictions on the use of nickel in alloy steel will continue in force for the time being. This relaxation of control follows the recent announcement by the Council of O.E.E.C. of their decision to suspend molybdenum restrictions in member countries.

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* P. Schiller. "An Analysis of the Load on a Modern Electricity Supply System." *Jl. Inst. Elec. Engrs.*, Part II, 1944.

† D. H. Parry. "The Logical Approach to the Problems of Space Warming by Electricity." Paper before the Institution of Electrical Engineers, April 3, 1952.

CENTRELESS GRINDING MACHINE.

B.S.A. TOOLS, LTD., BIRMINGHAM.

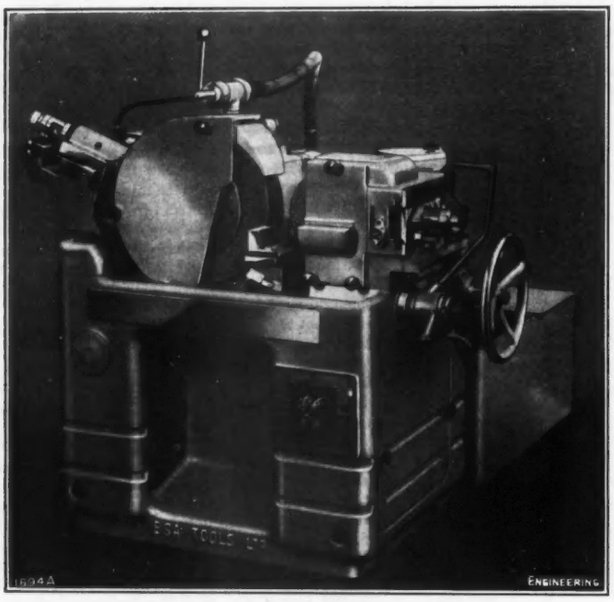


Fig. 1. The No. 4 Centreless Grinding Machine.

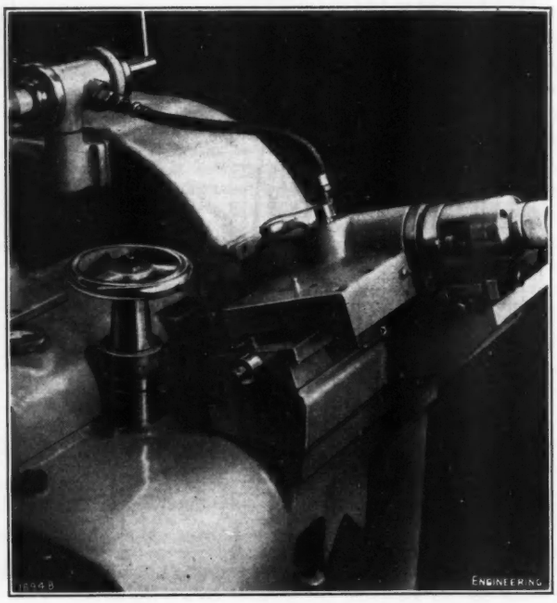


Fig. 2. Rear of Grinding-Wheel Head.

CENTRELESS GRINDING MACHINE.

Centreless grinding is probably one of the fastest methods of finishing cylindrical components. B.S.A. Tools, Limited, Marston Green, Birmingham, have developed a new centreless grinder, model No. 4, which will be made in place of their model No. 7. The new grinder, shown in Fig. 1, herewith, was displayed for the first time at the European Machine Tool Exhibition recently held in Brussels. The machine incorporates a number of technical refinements. Foremost among these is the control-wheel head shown in Fig. 3, which is fixed, the work-supporting base being made adjustable to accommodate the differing diameters of work. The capacity of the machine is from $\frac{1}{16}$ in. to 3 in. diameter for either the straight-through or plunge-cut method. Through-feed bar-grinding from $\frac{1}{16}$ in. to $\frac{3}{4}$ in. in maximum lengths of 10 ft. can also be performed with the assistance of the appropriate attachment. The finish obtained is extremely fine and a high degree of diametral and cylindrical accuracy is maintained. The machine handles plain cylindrical, tapered, shouldered, special-form or multi-diameter components.

Operation of the machine follows the general principles of centreless grinding. Plain cylindrical parts are ground by the straight-through method. In this case the head is set to produce the required diameter by means of a micrometer handwheel control, shown on the left of Fig. 2. The work-pieces are then fed in at the front of the machine, pass between the grinding wheels, and leave the machine at the other end. Components having a shoulder or special form are ground by the plunge-cut method. The work-piece is placed on the work-plate with the grinding-wheel withdrawn. The wheel is then fed forward to a stop by the hand lever. On completion the work is automatically ejected by a plunger as the lever is returned to open the wheels. All the principal controls for carrying out these operations are grouped together for ease of operation. The electrical controls are all on one panel, as can be seen in Fig. 1.

The grinding-wheel head is mounted on one flat and one V-slide, both of which are automatically lubricated. The slides remain covered at all times as protection against the abrasive dust and metal particles. The wheel-head can be moved by either the handwheel or lever, both of which can be seen in Figs. 1 and 3. Extremely fine feed is obtained by means of the micrometer handwheel, graduated in 0·001 in. The base of the wheel-head forms a well from which oil is pumped through a filter to the bearings, and indicators are provided to show the flow and level of the oil. A hollow duct incorporated in the grinding-wheel guard, feeds the coolant directly on to the work area and separate facilities have been fitted to allow a direct flow of coolant to be directed on to the diamond when truing the grinding wheel. This operation is carried out at the rear of the grinding wheel from the slide, shown in Figs. 1 and 2, mounted on the head casting, and a power-drive attachment can be fitted. This consists of a separate motorised unit, which simplifies and assists in the truing operation, particularly for form truing.

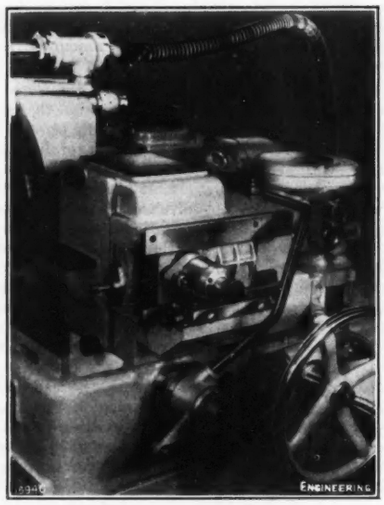


Fig. 3. Control-Wheel Head and Truing Slide.

The grinding-wheel head spindle is made from Nitralloy, heat-treated, ground, and lapped to fit bearings of fine-grained phosphor bronze. The bottom halves of the bearings are firmly fixed in the wheel-head and the top halves are spring-loaded to assist in maintaining correct bearing adjustment under all conditions. Lubrication of the bearings is automatic. The drive to the grinding-wheel is from a 10-h.p. electric motor which is screen-protected and gives a high torque. It runs at 1,455 r.p.m. and is precision balanced. The motor is mounted directly below the end of the grinding-wheel spindle and a V-rope drive is fitted. A micrometer control incorporated in the grinding-wheel spindle gives lateral adjustment of the spindle for correcting the position of the wheel after its side face has been trued. Particular attention was paid to the design of the grinding-wheel head to ensure that the total power absorbed by the grinding wheel remained low and constant. This enables the machine to produce accurate work immediately it starts up, without an initial period for warming the bearings. The grinding wheel runs at a constant speed of 1,270 r.p.m.

The control-wheel head, which is fixed, has been made in this manner to give additional rigidity to this section of the machine, upon which the control of the work-piece depends. It also saves time when re-setting. The control wheel of the machine determines both the speed of rotation and the rate of feed through the machine when straight-through grinding. The angle at which it is set governs the rate of feed. The control wheel, spindle, and drive are, therefore, arranged to pivot up to a maximum of 7 deg. from the horizontal. In addition, the whole of the control-wheel head can be swivelled in either direction in the horizontal plane while the machine is in motion to aid in setting-up. For example, should a test-piece of a plain cylindrical component show a slight taper a correction can be made by swivelling the head around slightly instead of re-dressing the wheel. By this method, the life of the wheel is prolonged, besides reducing the setting-up time.

The spindle of the control wheel runs in a tapered bronze bearing at the front and a pre-loaded ball bearing at the rear. The control wheel fits directly on to the spindle and it has four working speeds from 18 to 59 r.p.m. An additional speed of 392 r.p.m. is provided for truing, and this can be obtained through a separate clutch. The drive is from a single-speed motor through a worm and wheel and pick-off gears. A diamond-truing slide

ANALOGUE COMPUTOR.

SHORT BROS. AND HARLAND, LTD., BELFAST.

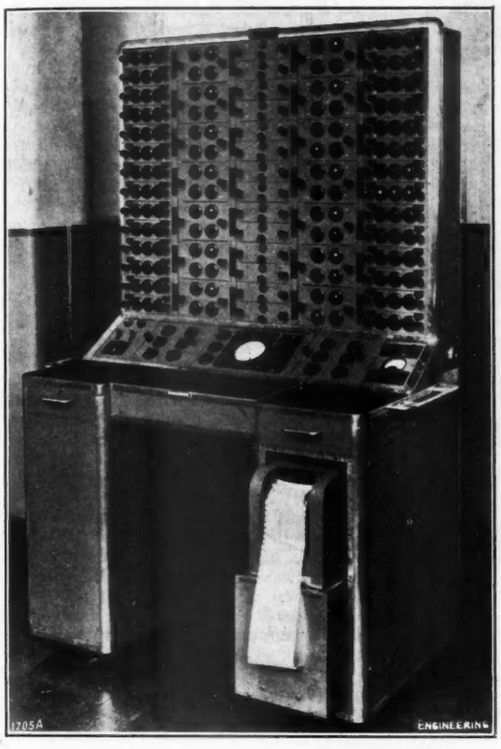


FIG. 1. ANALOGUE COMPUTOR.

Fig. 2.
ARRANGEMENT FOR SOLVING A SINGLE SECOND-ORDER DIFFERENTIAL EQUATION.

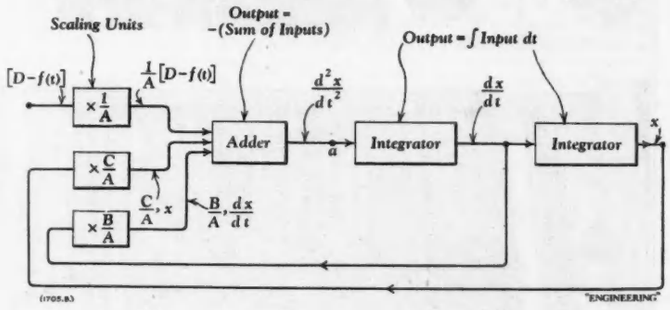
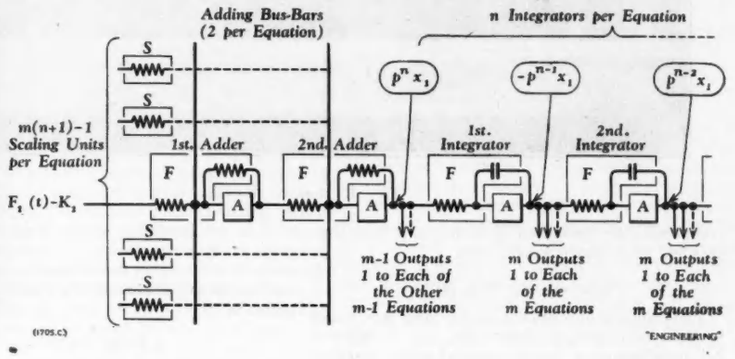


Fig. 3. *COMPUTOR ARRANGEMENT: GENERAL CASE OF m EQUATIONS OF n^{th} ORDER.*


Adding Bus-Bars (2 per Equation)
n Integrators per Equation
m(n+1)-1 Scaling Units per Equation
1st. Adder
2nd. Adder
1st. Integrator
2nd. Integrator
m-1 Outputs 1 to Each of the Other m-1 Equations
m Outputs 1 to Each of the m Equations
m Outputs 1 to Each of the m Equations
(1705.C)
"ENGINEERING"

is situated at the rear of the control-wheel head (Fig. 3) similar to that on the grinding-wheel head.

The work-base of the machine is fitted with a micrometer type of control, and different diameters of work can be accommodated with the aid of this adjustment and the micrometer control on the grinding wheel. An important part of the work-base is the work-plate, on which the work is supported while being rotated by the control wheel. Three types of plate are available : a chilled cast-iron work-plate, an inserted-blade type, and a Stellite plate. For special work, plates of tungsten-carbide can be obtained.

A coolant pump arranged so that its bearings are not submerged supplies coolant from a tank of large proportions through a pipe, which can be seen in Fig. 1, to the grinding head. The pump has its own motor and a magnetic filter can be attached to the tank if required. A large range of additional equipment and attachments for use with this machine are available, including guide arms, guide plates, work chutes and delivery trays for use on straight-through grinding, an automatic ejector for synchronising with the plunge-feed lever, special formers for form-truing and a bar-grinding attachment with stationary guides to accommodate bars from $\frac{1}{16}$ in. to $\frac{3}{4}$ in. in lengths of up to 10 ft. The sole agents in Great Britain for this machine are Burton, Griffiths and Company, Limited, Marston Green, Birmingham.

CANADIAN JET-ENGINE FACTORY.—The Hawker Siddeley Group announce that the new jet-engine plant at Malton, Ontario, owned by the Canadian Government, and leased and operated by A. V. Roe Canada Ltd., has been purchased by the latter company.

REPORT ON THE CENSUS OF PRODUCTION FOR 1950.—Volume 12 of the report on the census of production for 1950 was published on September 15. It covers the gas supply industry, the electricity supply industry, and water undertakings. Copies may be obtained from H.M. Stationery Office, York House, Kingsway, London, W.C.2, price 1*s.* 6*d.*, postage 1½*d.* extra.

A NEW ANALOGUE COMPUTOR.*

By E. LLOYD THOMAS, B.Sc., A.C.G.I.

THE increasing necessity for large-scale calculation in the design of aircraft has, in recent years, emphasised the lack of adequate computational facilities and has transferred attention from the problem of formulation to that of solution. Thus, unless a reliable simple theory is available, the designer is forced to base his design on approximate formulæ which do not always reflect current trends in a fast developing science. The more elaborate theory is therefore usually applied only as a check to the final design; and much valuable time is wasted while such computations are carried out, even if they do not indicate the need for major structural modifications. The psychological effect of such protracted calculations on desk machines is to cast considerable suspicion on the results, which are seldom accepted unreservedly unless checked step by step or by re-computation. An urgent demand has therefore arisen for a computor which will solve simultaneous differential equations quickly, with reasonable accuracy, and present the results in a form convenient for observing the effects of varying the parameters of the system.

In other fields, particularly servo-mechanisms, a similar need exists, but it is not always possible to write down exact equations representing the behaviour of the system. The result is that equipment is often designed by trial and error methods—sometimes, as in the case of automatic pilots, under costly operating conditions. With this type of problem, the requirement is for a computor which will represent the transfer functions of the various parts of the equipment to enable the performance of the whole system to be studied. In addition, it is an advantage if actual components of a servo-mechanism can be coupled up to the computor for simulation purposes.

These various requirements are satisfied best by an electronic instrument operating on the analogue rather than the digital principle. Although an analogue computor is not capable of the same degree of accuracy as a digital machine, most aerodynamic and servo problems only require answers correct to within a few per cent. A digital computor would probably be larger and more expensive for a given capacity and, besides, would give no insight into the physical behaviour of the system under investigation.

One of the main advantages of the electronic analogue type of computor is that, in a few hours, it is possible to run through a range of solutions which might take days or weeks to compute on paper. An additional advantage is the ability to alter the effective time scale, so that events which actually occur over a period of several seconds or more may be compressed into one-tenth or one-hundredth of that time for more convenient observation.

Although several analogue computors have been constructed in this country during recent years, they have usually been designed as special-purpose instruments intended for only a limited range of problems and built individually. Their cost has therefore been high; and this, coupled with their large size, has put them beyond the reach of many potential users. With these considerations in mind, the Research and Development Department of the Precision Engineering Division of Short Brothers and Harland, Limited, has evolved a general purpose analogue computor of compact design, incorporating several novel features, and designed for economical quantity production. The consol of the machine is illustrated in Fig. 1, on this page. Although it is realised that one type of computor can never be equally suitable for all types of problem, it is felt that the slight increase in operating time sometimes required to perform certain calculations on a universal computor,

* Communication from the Precision Engineering Division, Short Brothers and Harland, Limited, Belfast. Abridged.

ANALOGUE COMPUTOR.

SHORT BROS. AND HARLAND, LTD., BELFAST.

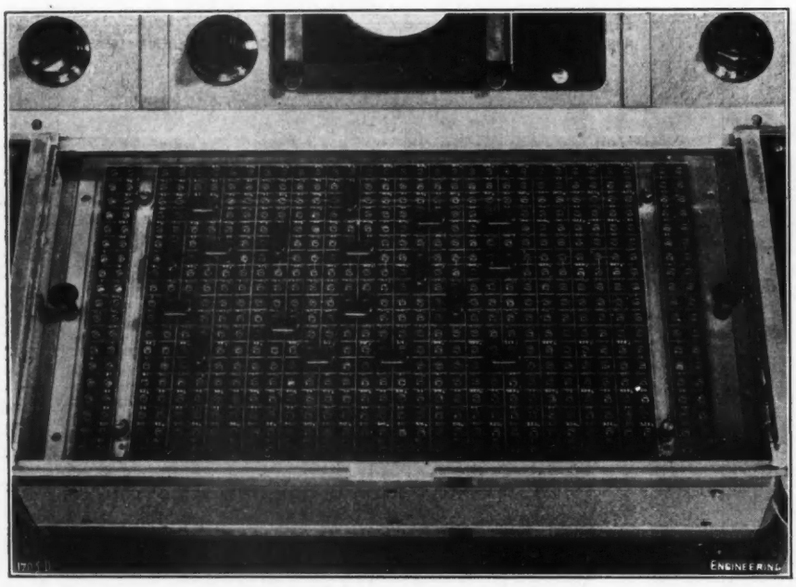


Fig. 4. Set-up Panel.

compared with specialised instruments, is more than justified by its much wider scope.

Principle of Operation.

The principle of operation of the computor, which is of the differential analyser type, may be followed by considering a simple second-order equation such as :

$$A\frac{d^2x}{dt^2} + B\frac{dx}{dt} + Cx = 0, \quad \ldots \quad (1)$$

where A, B, and C are constant coefficients. This may be re-written as

$$\frac{d^2x}{dt^2} = -\left[\frac{B}{A}\frac{dx}{dt} + \frac{Cx}{A}\right]. \quad \ldots \quad (2)$$

If these terms are represented by time-variable voltages, and are all zero at $t = 0$, then equation (2) can be satisfied by an electrical system arranged as in Fig. 2, page 447. This network is obtained by assuming that $\frac{d^2x}{dt^2}$ exists at point a; $\frac{dx}{dt}$ and x are produced by successive integration and then added, in the proportions indicated by the appropriate coefficients, using a device whose output is equal to the sum of its inputs but reversed in sign. This output must therefore be $\frac{d^2x}{dt^2}$. The required solution will be the variation with time of the dependent variable x, or one of its derivatives, to a time-variable forcing function $f(t)$. This is obtained by injecting a suitable voltage transient as an additional input to the adder, and observing the response at the appropriate point.

If the equation includes a constant term, it may be represented by

$$A\frac{d^2x}{dt^2} + B\frac{dx}{dt} + Cx + D = f(t),$$

or

$$\frac{d^2x}{dt^2} = -\left\{\frac{B}{A}\frac{dx}{dt} + \frac{C}{A}x + \frac{1}{A}[D - f(t)]\right\}.$$

For convenience, therefore, a constant term is generally included as part of the forcing function. In a practical computor the integrators may also introduce a reversal of sign ; and due account must be taken of this in setting up the problem.

In the examples referred to later both the integrator coefficients are assumed to be unity. However, this is not essential, particularly when the computor is made to operate on a time scale other than unity, and it is often convenient to choose integrator coefficients which are some multiple or sub-multiple power of 10.

Basic Design.

The first stage in the development of the computor was to decide on the size and capabilities of the instrument. This was approached from the point of view that a single unit should be large enough to cope with the day-to-day requirements of a design office or development laboratory, and that more difficult problems should be tackled by linking two or more computors together. The advantage of this arrangement is that, for a given outlay on computing equipment, a considerably greater volume of ordinary work can be handled, while still providing for the occasional more complicated problem. A number of typical problems were considered to settle this point. As a result, it was decided that one computor should be capable of solving three simultaneous linear second-order differential equations as in, for example, a ternary flutter problem with all terms present.

For the solution of such problems, only a few different types of computing element are needed. The essential elements are those which perform the operations of integration, addition and adjustment of scale. Now, these facilities may either be provided as a number of single-purpose integrators, adders and scaling units, or as an equivalent number of general-purpose amplifiers which may be associated with various passive networks to perform the same operations. Although, at first sight, the former arrangement seems more convenient, it leads to an uneconomic design because enough elements of each type must be provided to cope with any problem and therefore for most problems there will always be a considerable number of idle units.

In the prototype of the Short computor, the alternative principle was adopted, and three basic types of computing element provided. These are :—(1) scaling units, which are essentially three-decade variable resistances ; (2) function units, consisting of various resistance/capacitance networks, which may be selected by switches ; and (3) amplifiers, consisting of high-gain five-valve units which may be used in combination with the scaling and function units for addition, integration and all other linear operations in computation and simulation.

Fig. 5. NORMAL DISPLAY.

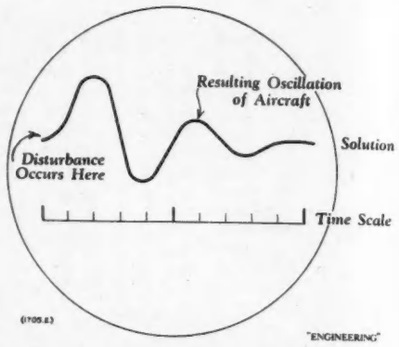


Fig. 6. SHOWING EFFECT OF INCREASING INTEGRATOR TIME CONSTANTS OR SWEEP SPEED.

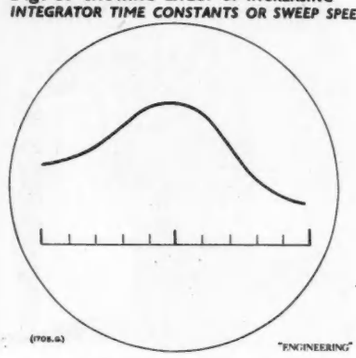
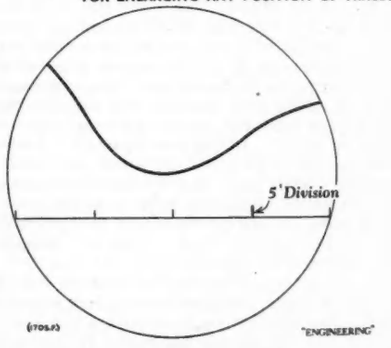


Fig. 7. SHOWING EFFECT OF SWEEP EXPANSION FOR ENLARGING ANY POSITION OF TRACE.



The way in which these units are interconnected for the solution of differential equations is shown in Fig. 3. Two adders are shown in the circuit to permit sign reversal where required, and the whole arrangement has to be repeated for each equation of the problem. In order to meet the original specification with some reserve of capacity, 14 amplifiers, 14 function units, and 28 scaling units were provided in the prototype instrument. However, to meet the demand that three computors linked together should be capable of tackling a general six-degrees-of-freedom problem, and because of certain restrictions in the interconnections, the production version will be provided with 18 amplifiers and a corresponding number of function and scaling units.

Description.

The appearance of the prototype instrument is shown in Fig. 1. It is built in the form of a double-pedestal desk surmounted by a shallow rack, and is mounted on castors for ease of movement. The overall dimensions are only 5 ft. 9 in. high, 3 ft. 6 in. wide, and 2 ft. 2 in. deep. All the sub-assemblies (such as the computing units) are designed to slide into the framework and to be secured with quick-

release fasteners, electrical contacts being made automatically with suitable connectors. The computor derives its power (approximately 1 kW) from the normal mains supply through a number of power units which are fitted into the left-hand pedestal of the desk. The pen recorder, with its associated power unit and amplifier, is accommodated in the right-hand pedestal.

Set-Up Panel.—The computing units are interconnected for each problem by inserting small plugs into a "set-up panel," illustrated in Fig. 4, opposite, which is recessed into the top of the desk and covered by hinged flaps when not in use. This feature avoids the usual tangle of telephone plugs and cords which disfigures most computors. As a further simplification, blank charts are provided which can be marked with the positions of the plugs required for any problem; the chart can then be used as a guide when setting up the computor, and subsequently filed as a record.

Display.—With a computor of this type, two methods of working are possible. One is to choose a slow time scale, of the order of seconds, initiate the forcing function (usually a voltage step) manually, and obtain the solution as a graph from a recorder of some kind. The other is to operate repetitively with a fast time scale, reducing the time constants of the system if necessary, and observe the solution with a cathode-ray oscilloscope. This second method is generally more convenient, since it gives a steady picture on a screen, and enables the operator to observe immediately the result of changing the constants of a system. However, it may not be satisfactory for simulation, because if actual components of a system are being used in a set-up they will generally have to work on a true time scale.

Facilities have therefore been provided for both kinds of display by building a cathode-ray oscilloscope into the computor for normal use, and also arranging for a pen recorder to be fitted optionally. This enables an operator to set up a problem, determine the optimum constants by trial and error visually on a fast time scale, and then turn to a slow time scale to obtain a permanent record from the recorder.

Timing.—For repetitive operation the timing sequence is as follows. Each cycle of operation is divided into two approximately equal intervals. At the beginning of each cycle, the two spots of the double-beam cathode-ray tube start from the left-hand side of the screen and begin to move at a constant speed across it. At the same instant, the forcing function is injected into the computing network; since the vertical deflection of the upper spot is arranged to be proportional to the magnitude of the voltage appearing at some point in the system, it will, as it moves, trace out the time graph, as shown in Fig. 5, opposite, of the quantity represented by this voltage, which is the required solution. The lower spot always moves horizontally in synchronism with the upper, but its vertical movement is normally controlled by a timing circuit so that a series of marks is produced which divides the trace into ten equal sections. The "0," "5," and "10" marks are accentuated, and the trace has the appearance of a luminous scale below the actual solution. In this way, the horizontal ordinates of a solution may be read off without the use of a physical scale or graticule. Alternatively, the lower spot may be used to display any other term in the system simultaneously with that shown by the upper trace.

At the end of the first half of each cycle, when the two spots have reached the right-hand side of the screen, a system of relays (one for each amplifier) restores the quiescent condition, and, during the second half of the cycle, corrects any drift in the amplifiers. While this is occurring the spots are extinguished.

The sweep speed may be set to any of the following values:

Sweep Duration.	Corresponding Repetition Rate.
Milli-seconds.	
30	15 sweeps per second (approx.).
100	5 sweeps per second.
300	3 sweeps in 2 seconds (approx.).
1,000	1 sweep in 2 seconds.

The effect of turning the speed control to a shorter sweep duration will be to expand the trace, as shown in Fig. 6, so that only the initial portion of the solution is shown, but to a larger horizontal scale. The same effect can, of course, be produced by leaving the sweep speed unchanged, and reducing the coefficients of all the integrators. A sweep expansion control is also provided to enable an enlarged view of any part of the solution to be obtained, such as that illustrated in Fig. 7.

In practice, it will probably be found that a moderately high repetition rate is most convenient for general work. However, if it is desired to obtain a record of the solution on the pen recorder, the timing system may be switched off, the integrator coefficients set to give a solution lasting several seconds, and the forcing function applied by the manual operation of a switch. The normal forcing function, which is generated internally by the computor, is a voltage step whose amplitude may be adjusted on the control panel. Alternatively, any other forcing function, such as a sine wave, may be fed into the computor from an external source via the sockets provided.

Drift Correction and Clamping.—Two other important features of the instrument are the incorporation of "drift correction" and "clamping." All direct-current amplifiers are prone to drift, that is, a voltage is liable to appear across the output terminals when the input is zero, and in most computors the amplifiers must be checked and adjusted periodically. In the Short computor, however, advantage has been taken of the repetitive nature of the computing cycle, by arranging for correction to be applied automatically during the quiescent interval between successive solutions. The principle of the system employed is to provide a capacitor in series with each amplifier, arranged to be switched by a relay at the start and finish of each sweep. During the quiescent period, each capacitor becomes charged to the drift voltage of its associated amplifier and then, at the beginning of each sweep, it is switched so as to be in series with the amplifier. The combination of capacitor and amplifier may then be regarded as a drift-free amplifier for as long as the capacitor retains its charge, provided the drift itself is not changing rapidly. This system requires one relay for each computing amplifier and all the relays are driven synchronously by the timing circuit. An additional advantage of the scheme is that the relays can also be arranged to "clamp" the computing system at the end of each sweep, thus enabling the computor to cope with divergent solutions or unstable systems. Without clamping, it would be impossible to obtain repetitive solutions of such problems.

Operation.—The persons most likely to use the instrument for computation will be graduates of physics or mathematics, who will be fully capable of formulating the problems being presented to it. It is not essential for such users to have any electrical knowledge, although it may help in planning the set-up for the most economical use of the computing elements if the operator has some knowledge of the processes involved. Engineers familiar with servo mechanisms should have no difficulty in applying the computor to their problems, and in connecting it up with the various external systems.

In setting up the machine, the system, or equations, are reduced to a block diagram of the computing elements involved, using one of the record charts already mentioned, and the corresponding plug positions and dial settings marked on the diagrams provided. The setting-up of the computor, once the problem has been planned in this way, is very simple, and may be left to a semi-qualified assistant. Having established the problem, it only remains to select the desired time scale and forcing function, and arrange for the required variable to be displayed on the screen. For a rough record, the solution may be traced in pencil on a roll of "Kodatrace" film contained in a cassette adjacent to the screen. For more accurate results the pen recorder may be used, provided the integrator coefficients are adjusted to give a solution whose significant frequencies are within the range of the recorder.

[The article here gives three examples, with illustrations, of problems that had been resolved by use of the computer. Two of the problems specifically related to aircraft: those of the lateral dynamic stability of an aircraft, a problem involving four simultaneous first-order equations, and of ternary flutter of a control surface. The third example related to a servo mechanism of the type used in a second-order position-control system.—Ed., E.]

FURTHER DEVELOPMENT.

In its present form, the computor will only deal with linear systems which are initially in a quiescent condition. However, several additional types of computing element now under development, particularly a non-linear function generator and a multiplier, will remove these restrictions and extend the scope of the instrument to problems that are not amenable to calculation by normal paper methods. The function generator, for example, will permit the investigation of the effects of such components as non-linear hydraulic valves in a servo system. It is also intended to make provision for the introduction of "initial conditions" so that studies may be made of the effect of applying the forcing function to a system which is already in a pre-determined state of disturbance. For these reasons, the production version of the computor will have a modified panel layout which will enable these additional computing elements to be interchanged with the basic units as optional facilities.

NOTES ON NEW BOOKS.

Small Transformers and Inductors.

By K. A. MACFADYEN. Chapman and Hall, Limited, 37, Essex-street, London, W.C.2. [Price 37*s.* 6*d.* net.]

WE have examined this book without discovering the author's definition of a small transformer, except that it is merely an incidental component in some larger scheme. We infer, however, that its capacity is measured in volt-amperes rather than in kilowatts. In the design of such transformers there is a wide gulf between conventional theory and successful construction. The main object of the book is therefore to bridge this gulf by presenting on a common basis the general theory, the design procedures and the technical data for materials in common use. The author goes into all these matters in considerable detail and although he claims that the standard required for their appreciation is well below that of a physics or engineering degree we feel that it is to the mathematically inclined to whom it will most appeal. It will, however, provide the specialist with a useful summary of the present position and the technologist with some insight into a subject which is not without its complications.

Motion and Time Study Applications.

By PROFESSOR RALPH M. BARNES. Second edition. John Wiley and Sons, Incorporated, 440, Fourth-avenue, New York 16, U.S.A. [Price 3 dôls.]; and Chapman and Hall, Limited, 37, Essex-street, London, W.C.2. [Price 24*s.* net.]

THIS book is a collection of reports, papers and articles of a most miscellaneous kind, but all relating to some aspect of time or motion study. There are 48 of these contributions, many of which appear to be making their first public appearance; others are reprinted from periodicals, trade literature and the proceedings of technical societies. They range from an extract taken from a report of the Industrial Fatigue Research Board, published by H.M. Stationery Office in 1924, concerning the energy expended in carrying a load, to the best ways of folding table napkins or making hotel beds. In a preface to the volume, Professor Barnes explains the purpose of this collection. He is Professor of Engineering and Production Management at the University of California, and the work has been prepared to serve as a text-book for students taking a course in the field of motion and time study. He refers, throughout, to the men for whom the course is intended as "industrial engineers"; the term "production managers" is probably the nearest British equivalent. He states that "in the past, the industrial engineer has been primarily concerned with increasing the productivity of the direct factory workers," but that with the "increasing complexity of modern industry," he must attack such problems as the utilisation of plant, and quality of product. There is not likely to be any disagreement from Professor

Barnes' opinion that it is desirable for the industrial engineer "to be familiar with the technical and shop conditions of the business in which he is working." This familiarity can only be attained in actual employment, but the college graduates and others who attend the training course will be assisted in fitting themselves into their industrial niche by instruction on the principles of their occupation.

Alternating-Current Electrical Engineering.

By Philip Kemp, M.Sc.Tech., M.I.E.E. Eighth edition. Macmillan and Company, Limited, St. Martin's-street, London, W.C.2. [Price 36*s.* net.]

It is hardly necessary to commend a text-book which has been in active existence for thirty-five years, has reached its eighth edition and has so well established itself in technical colleges. This latest version is naturally a very different thing from that which appeared in 1918, but the author's method has not altered. His purpose is to instruct students in the principles on which electrical engineering is based, entering sufficiently into practical aspects to illustrate their application. Students are likely to grasp more fully the implication of principles if they understand something of the way in which they bear on, and control, the design of plant and apparatus. The book is not, however, intended to be a treatise on detail design. It is a substantial volume, containing 680 pages, but it does not deal with the extensive subject of electronics, which has developed in such a remarkable way since the book was first published. Broadly speaking, it is concerned with power plant and its attendant control apparatus, but as the mercury-arc rectifier now occupies such a prominent position in practice, the subject of electronics is dealt with in so far as is necessary in describing the principles of arc rectifiers. The production of the book is in every way worthy of the standards associated with the name of its publishers.

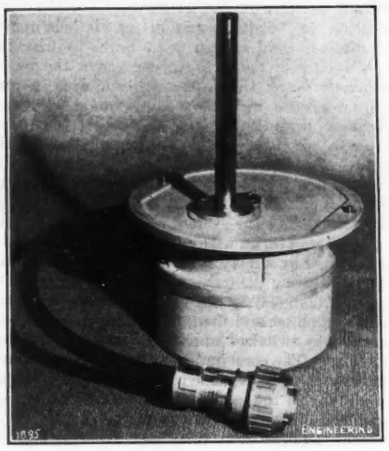
CONTRACTS.

During August the British Electricity Authority placed contracts for power-station, transforming-station and transmission-line equipment amounting, in the aggregate, to 7,063,046*l.* The principal orders included :—For Brighton "B" power station: piling for the foundations for two turbo-generator sites, with Holloway Bros. (London), Ltd.; for Cowes power station: the superstructure, with John Croad, Ltd.; for South Denes power station, Yarmouth: two 550,000 lb. per hour boilers, with International Combustion, Ltd.; two 60,000-kW turbo-generators and auxiliary apparatus, with the Metropolitan Vickers Electrical Co., Ltd., and condensing and feed-heating plants for two 60,000-kW turbo-generators, with Vickers-Armstrongs Ltd.; for Castle Donington, power station, near Derby: the main building superstructure, with Taylor Woodrow Construction, Ltd.; for Northampton power station: the steel framework to the boiler and turbine houses, with Dorman, Long & Co., Ltd.; for Nottingham power station: the foundations and culverts, with Taylor Woodrow Construction, Ltd., and a 72-MVA transformer and a 6-MVA transformer, with the Metropolitan-Vickers Electrical Co., Ltd.; for Hams Hall "C" power station, near Birmingham: 3·3-kV auxiliary switchgear, with A. Reyrolle & Co., Ltd.; for Meaford "B" power station, Stone, Staffordshire: a 515,000-lb. per hour boiler, with Babcock and Wilcox, Ltd.; for Uskmouth power station, Newport, Monmouthshire: condensing and feed-heating plant for a turbo-generator set, with Vickers-Armstrongs Ltd.; for Doncaster power station: the second section of the superstructure, with J. Gerrard & Sons, Ltd.; for Ferrybridge "B" power station, Yorkshire: a generator transformer, with C. A. Parsons & Co., Ltd., and two 10-MVA transformers, with the Fuller Electrical and Manufacturing Co., Ltd.; for Barony power station, Ayr: structural steelwork for the main building and annexes, with the Colville Constructional Co., Ltd.; for Andover substation, Hampshire: 132-kV 2,500-MVA switchgear, with the British Thomson-Houston Co., Ltd.; for Elstree substation: site and foundation works, with J. L. Eve Construction Co., Ltd.; for Pyle substation, Glamorgan: 132-kV switchgear, with the English Electric Co., Ltd.; for Creyke Beck substation, Yorkshire: 132-kV 2,500-MVA switchgear, with A. Reyrolle & Co., Ltd.; and for Ferrybridge "B" substation, Yorkshire: site and foundation works, with M. Harrison & Co. (Leeds), Ltd.

AIRSTREAM DIRECTION DETECTOR.

To measure the direction of airflow past an aircraft, an instrument manufactured by Messrs. Ferranti, Limited, Hollinwood, Lancashire, is now available in the United Kingdom. The Ferranti airstream direction detector, shown below, operates on the principle of an instrument developed by Specialities Incorporated, New York, U.S.A., and is interchangeable with it, but incorporates a number of detail modifications. The airstream direction indicator may be mounted in a position to indicate sideslip, or to indicate angle of incidence, facilitating cruising at the optimum lift-drag ratio, and giving a useful safety indication at take-off and landing.

The detector consists of a small cylindrical probe, extending through the aircraft wing or fuselage skin and projecting into the airstream. The probe is mounted in two stainless-steel ball races so that it



is free to rotate, but since it is cylindrical the airflow exerts no torque directly on it. Two narrow slots are cut in the probe surface, parallel with the probe axis and 90 deg. apart. The dynamic air pressures at these two slots are led separately up the probe, and through two ports into a paddle chamber, where they operate on opposite sides of a light paddle. The latter is coupled to the probe through a 10-to-1 reduction gearing.

If the two slots are not symmetrical relative to the direction of the local airflow, the pitot pressures developed in the two slots will not be equal, and the pressure difference, proportional to the misalignment angle and to the square of the indicated airspeed, will drive the paddle in a direction tending to equalise the pressures at the two slots. At an indicated airspeed of 100 knots and an error from the true airstream direction of 0·1 deg., the corrective torque on the probe is 25 gramme-centimetres. Since the instrument operates on the null principle, once the minimum airspeed required to operate the instrument has been exceeded, the angular reading is independent of the air speed and density.

In the standard detector, an electrical pick-off system consisting of two independent potentiometer outputs each having a resolution of about 0·1 deg. provides an indication of the angular movement of the probe shaft.

The consistency of the detector is better than 0·1 deg. The amplitude response with frequency is level up to 5 c.p.s. at an indicated airspeed of 200 knots. The standard detector has an angular movement of 20 deg.; it can be increased to 40 deg., but only one output will then be available unless the depth of the instrument is increased.

For de-icing, a 65-watt heater is fitted in the probe and a 12-watt heater is provided in the case. The heaters operate from a 28-volt direct-current supply and are controlled by a thermal switch on the probe shaft, which prevents damage to the instrument if the heater is switched on at ground level. Double filters in the probe and ports prevent dirt entering the paddle chamber.

BOOKS RECEIVED.

Government of Northern Ireland. Memoirs of the Geological Survey. The Composition and Origin of the Antrim Laterites and Bauxites. By V. A. Eyles. *With Mineral Determinations by X-Ray Methods.* By Dr. F. A. Bannister and others. H.M. Stationery Office, 80, Chichester-street, Belfast; and Kingsway, London, W.C.2. [Price 12*s.* 6*d.* net.]

Verdichtungstechnik und Verdichtungsgeräte im ausländischen Erdbau. By Dr.-Ing. Heinz Pösch. Wilhelm Ernst und Sohn, Hohenzollerndamm 169, Berlin-Wilmersdorf, Germany. [Price 9.80 D.M.], and Lange, Maxwell and Springer, Limited, 242, Marylebone-road, London, N.W.1. [Price 17*s.* 2*d.*]

Year Book of the Heating and Ventilating Industry, 1953. Technitrade Journals, Limited, 8, Southampton-row, London, W.C.1. [Price 7*s.* 6*d.* net.]

Statistics for Technologists. By C. G. Paradine and B. H. P. Rivett. English Universities Press, Limited, St. Paul's House, Warwick-square, London, E.C.4. [Price 25*s.* net.]

Catalytic Enrichment of Industrial Gases by the Synthesis of Methane. Fuel Research Technical Paper No. 57. H.M. Stationery Office, Kingsway, London, W.C.2. [Price 2*s.* net.]

An Introduction to the Theory and Application of Motion Study. By Anne G. Shaw. Revised edition. Harlequin Press Company, Limited, Old Colony House, South King-street, Manchester, 2, and 20, Irving-street, London, W.C.2. [Price 6*s.* net.]

Building Construction and Drawing. By George A. Mitchell, and A. M. Mitchell. Part I. *Elementary Course.* Twenty-first edition. B. T. Batsford, Limited, 15, North Audley-street, and 4, Fitzhardinge-street, London, W.1. [Price 15*s.* net.]

Marine Steam Boilers. By J. H. Milton. George Newnes, Limited, Tower House, Southampton-street, London, W.C.2. [Price 27*s.* 6*d.* net.]

Principles and Practice of Radar. By H. E. Penrose and R. S. H. Boulding. Fourth revised and enlarged edition. George Newnes, Limited, Tower House, Southampton-street, London, W.C.2. [Price 50*s.* net.]

Factory Health Safety and Welfare Encyclopædia. By C. Conway Plumbe. The National Trade Press, Limited, Tower House, Southampton-street, London, W.C.2. [Price 30*s.* net.]

TRADE PUBLICATIONS.

Corrosion in Power Plants.—Messrs. G. & J. Weir, Ltd., Cathcart, Glasgow, S.4, have sent us a well-illustrated pamphlet dealing with the application of their "Optimum" de-aerators to land and marine work. The phenomenon of corrosion is adequately described, as are the operating principles of the de-aerator, and details are given of a number of typical installations where this equipment is being used.

Filter Cloths.—Rediweld, Ltd., 15/17, Crompton Way, Crawley, Sussex, have sent us a number of leaflets dealing with their synthetic filter cloths. These cloths, which are obtainable in varying weaves and grades, are known as Redivin and Redithene. The former has a polyvinylchloride base and the latter is made from polythene. They also list the Flexolith plastic filters of which there are two kinds: Flexolith "A," which is made of porous poly-methyl-methacrylate, is resistant to acids and alkalies, and has an average pore size of 0·008 mm.; and Flexolith "W," which is made of plasticised P.V.C., and is used mainly for the manufacture of filter candles.

Maximum-Amplitude Measuring Set.—A set for measuring the maximum amplitude of transient phenomena is described in a pamphlet received from Standard Telephones and Cables Ltd., Aldwych, London, W.C.2.

Flameproof Switches for Belt Conveyors.—Messrs. E. N. Mackley & Co., Gateshead-on-Tyne, have sent us a pamphlet describing their "Acomb" flameproof automatic control and protection switches for belt conveyors.

Electrical Equipment at Steel Works.—The General Electric Co. Ltd., Kingsway, London, W.C.2, have issued a pamphlet giving details of the equipment they have installed at the Margam, Abbey and Trostre works of the Steel Company of Wales.

Compressed-Air Equipment for Farms.—A leaflet issued by B.E.N. Patents, Ltd., High Wycombe, Buckinghamshire, describes compressed-air equipment for use on farms. Complete petrol-driven sets and many accessories are made.

Flameproof Motors.—Newman Industries, Ltd., Yate, Bristol, have published a catalogue of their flameproof motors. These are continuously-rated squirrel-cage models and either fan or naturally cooled. Powers range from ½ to 44 h.p. Full dimensions and performance data are given.

Aerofoil Marine Fans.—Messrs. Woods of Colchester, Ltd., Braiswick Works, Colchester, have published an illustrated pamphlet giving details of the manufacture and performance of their Aerofoil fans for marine use